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AIR CUSHION ICEBREAKING BOW (ACIB)

OPERATIONS REPORT
1983/84

Prepared for:
Transportation Development Centre,
Transport Canada
Montreal

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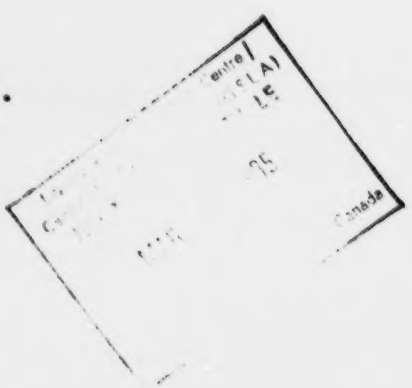

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17. Abstract

Successful trials with the Canadian Coast Guard (CCG) air cushion icebreaking bow (ACIB) were conducted during the 1982/83 icebreaking season. A contract was then let for repairs, modifications and engineering support for the ACIB ice management operations by the CCG with the ALEXANDER HENRY. Successful ice management tasks were conducted from February to April 1984. Approximately 260 nautical miles of ice were broken contributing significantly to the port of Thunder Bay being opened to navigation on schedule. The ACIB/ALEXANDER HENRY combination was also used in tests to break ice in slips between elevators. An entire slip, with ice thicknesses up to 90 cm, was cleared in a matter of minutes, with no undesirable loads on the dock structure.

Problems were experienced with damage to skirt and, particularly, to notch segments. This was the result of a number of factors: deterioration of the skirt material, design deficiencies, and inability to adjust cushion pressure and speed to ice conditions. Also the ACIB was operated in some situations where the ALEXANDER HENRY alone would have been equally effective - in very thin ice and in broken ice.

The average fuel consumptions of the combination over the season was 42.6 litres per kilometer, or 269 litres per hour.

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17. Résumé

Après le succès des essais de la Garde côtière canadienne avec la proue brise-glace à coussin d'air (ACIB), durant la saison 1982/1983, un marché a été contracté pour la réparation et la modification de cette proue, ainsi que pour le soutien technique nécessaire en vue des opérations de déglaçage à venir, avec le Alexander-Henry. De février à avril 1984, des opérations de déglaçage ont été effectuées avec succès, menant à l'ouverture d'environ 260 milles marins dans les glaces et permettant la réouverture du port de Thunder Bay à temps pour la saison de navigation. Le Alexander-Henry équipé de la proue a également été essayé pour ouvrir un chemin dans les bassins de chargement, entre les élévateurs. Ainsi, en quelques minutes, un bassin de chargement a pu être dégagé des glaces qui l'encombraient et dont l'épaisseur atteignait 90 cm, et ce, sans surcharger les parois.

Ces opérations n'ont cependant pas été sans endommager la jupe, notamment au voisinage de la structure de jonction. Plusieurs facteurs y ont contribué: détérioration du matériau de la jupe, mauvaise conception de base et impossibilité de régler la pression du coussin d'air et sa vitesse aux conditions glacielles rencontrées. En outre, la proue a été utilisée là où le brise-glace aurait pu suffire à lui seul, dans des glaces très minces ou brisées, par exemple.

La consommation moyenne pour l'ensemble ACIB/brise-glace durant la saison a été de 42,6 litres/km ou 269 litres/heure.

18. Mots-clés	19. Diffusion
Brise-glace. Proue brise-glace à coussin d'air. Plate-forme à coussin d'air. Thunder Bay.	Le CDT dispose d'un nombre limité d'exemplaires.

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PROJECT TEAM

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- Vulcan Machinery and Equipment Limited
- Rematech Industries, Division of Rubbertex Corporation Limited

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- Captain John McDonald, the officers and crew of the CCGS ALEXANDER HENRY
- Messrs. J. Leddy of Vulcan, and M.T. Skinner of Rematech
- Messrs. E. Gerow, E. Kavanagh and I. Jones of the Canadian Coast Guard, who were seconded to the ACIB for the trials
- Messrs. N.E. Rudback of TDC, and M.A. Ball and R.G. Wade of CCG
- Capt. G. Stieh, CCG Sub-Base, Thunder Bay
- Mr. H. Fowler of the National Research Council of Canada
- Mr. M. Rancourt of Supply & Services Canada, the Science Procurement Officer

and

- Mr. J. E. Laframboise of TDC, the Scientific Authority

SUMMARY

The Canadian Coast Guard air cushion icebreaking bow was designed and constructed by Hoverlift Systems Limited (HSL) in Calgary to CCG specifications. It was moved from Calgary to Thunder Bay in the Fall of 1981, and erected at the Port Arthur Shipbuilding Company, following which limited tests were carried out late in the 1981/82 winter season. These tests achieved a performance similar to that of the earlier icebreaking platform, ACT-100, and also revealed a number of deficiencies.

Late in 1982 a contract was placed for repairs, modifications and further testing with the tug THUNDER CAPE and the CCGS ALEXANDER HENRY. A mild season permitted the modification and maintenance to be done, but restricted the scope of the trials. Nevertheless, a lot of information was obtained and experience gained (see TP 4446E).

Very late in 1983 a further contract was placed for repairs, modifications and engineering support for the ACIB during ice management operations by the CCG. For this task the host ship was to be the CCGS ALEXANDER HENRY, but it was intended also to conduct trials with the tug THUNDER CAPE to explore the limits of its capability.

Due to the lateness of the contract, the ACIB was not ready for operations until 22 February 1984, but after that successful ice management tasks were conducted until 4 April, when the Master of the ALEXANDER HENRY was satisfied that the ACIB was no longer required.

Problems were experienced with damage to skirt and, particularly, to notch segments. This was the result of a number of circumstances: deterioration of the material, poor quality control, design deficiencies, and inability to adjust cushion pressure and speed to ice conditions. Also the ACIB was operated in some situations where the ALEXANDER HENRY alone would have been equally effective: in very thin ice and in broken ice. Much was learned and the lessons will be applied.

Circumstances did not permit the proposed trials with the THUNDER CAPE, but the ACIB/ALEXANDER HENRY combination was used in a test concerning breaking out the slips between elevators (Manitoba Pool No. 1). This was very successful, spectacular even, in spite of the caution dictated by the nature of the test. The entire slip, with ice thicknesses up to 90 cm, was broken out in a matter of minutes, with no undesirable loads on the dock structure.

SOMMAIRE

La proue brise-glace à coussin d'air (ACIB) de la Garde côtière canadienne (GCC), a été conçue et construite à Calgary par Hoverlift Systems Ltd (HSL) sur des spécifications de la GCC. Elle a été transportée de Calgary à Thunder Bay à l'automne 1981, et reconstruite au chantier de Port Arthur Shipbuilding Company; quelques essais ont été exécutés à la fin de la saison d'hiver 1981/82. Ces essais démontrèrent que les performances de l'ACIB étaient équivalentes à celles de la plate-forme ACT-100, déjà utilisée comme brise-glace à Thunder Bay, mais révélèrent aussi un certain nombre de défauts de conception.

Vers la find de 1982, un contrat a été octroyé pour réparations et modifications de l'ACIB et pour essais à l'hiver 1982/83 avec le remorqueur Thunder Cape et le CCGS Alexander Henry. Les travaux ont pu être faits à temps grâce à un hiver plutôt doux, ce qui toutefois a limité l'étendue des essais. Cependant l'expérience et les résultats obtenus furent intéressants (voir (TP446E).

Beaucoup plus tard, à la fin de 1983, un second contrat a été octroyé pour la préparation et l'entretien de l'ACIB durant ses opérations avec la GCC. A cet effet, l'ACIB devait opérer couplée au CCGS Alexander Henry, mais on avait prévu quelques essais avec le remorqueur Thunder Cape afin d'étudier son domaine d'opération conjointe.

A cause de la date tardive du contrat, l'ACIB n'a pu entrer en service avant le 22 février 1984. Elle a été opérée avec succès jusqu'au 4 avril, date à laquelle le Capitaine du Alexander Henry déclarait la tâche de l'ACIB terminée pour la saison.

Au cours de l'opération, les jupes présentèrent quelques problèmes d'usure, particulièrement les jupes de la structure souple de jonction avec le navire. Ces problèmes avaient diverses origines: détérioration du matériel avec l'âge, mauvaise qualité des collages de reprise, défauts de conception, et aussi impossibilité en cours d'opération d'adapter la pression du coussin d'air et la vitesse du navire aux conditions locales de glace. Ainsi l'ACIB était quelque fois opérée dans des types de glace où le Alexander Henry seul aurait suffi, soit dans la glace très mince (et coupante) et dans de la glace déjà brisée. Cette expérience sera appliquée à bon escient.

Il n'a pas été possible de faire des essais avec le Thunder Cape, mais le couplage ACIB/Alexander Henry a fait une première en brisant la glace à l'intérieur d'un poste de déchargement de grain. (Manitoba Pool No. 1). Cette opération a été très réussie, spectaculaire même, malgré la prudence dictée par la nature du projet. En quelques minutes, tout le poste couvert d'une couche de glace atteignant 90 cm a été dégagé sans produire de charges excessives sur la structure des quais.

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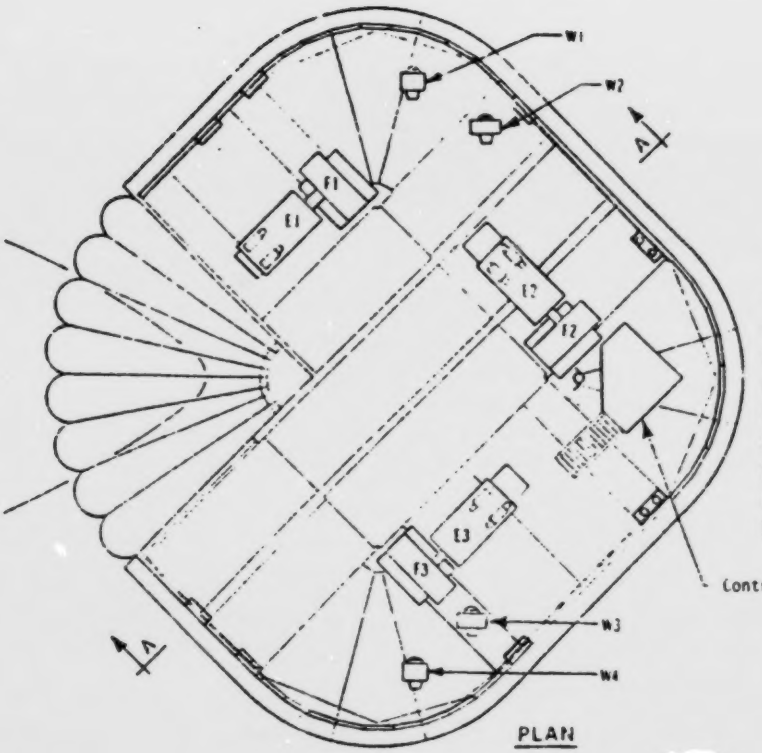
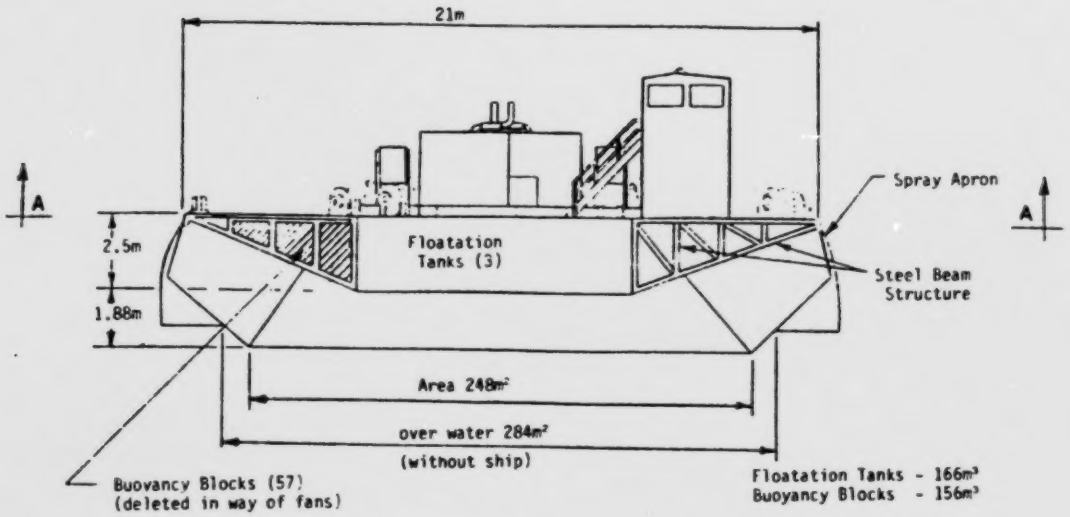
"B"	Meteorological Summary
"C"	Summary of Damage to Skirt Segments
"D"	Guide for Operators



ACIB - HSL 533

Weight	Cushion Pressure
Max. 300t	10 kPa
Min. 187.5t	6 kPa

Overall Beam = 24.7m
Cushion Beam at 10 kPa = 22.6m
W1,W4, - Notching winches = 160kN
W2,W3, - Transit winches = 100kN
E: Engines (3) each 490kW
F: Fans (3) each 35m³/s at 10kPa



SECTION A - A

FIGURE 1: AIR CUSHION ICEBREAKING BOW (ACIB) - GENERAL ARRANGEMENT

FIGURE 2: ACIB/CCGS ALEXANDER HENRY COMBINATION
ENTERING MANITOBA POOL No. 1
23 MARCH 1984

1.0 INTRODUCTION

1.1 BACKGROUND

For the past decade, Transport Canada has been actively developing air cushion icebreaking technology in order to explore the technical, economic and commercial implications of this innovative icebreaking phenomenon.

Full-scale testing with an icebreaking bow platform was first carried out at Thunder Bay in 1975/76. The air cushion vehicle used was a 100 ton capacity Arctic transporter (ACT-100) provided by Arctic Systems Ltd. The ACT-100 air cushion platform was modified to fit the bow of CCGS ALEXANDER HENRY. Compared to her normal performance, the icebreaker with the air cushion platform attached was able not only to break substantially thicker ice, but to do it while progressing at higher speeds, using much less fuel and leaving a wider track for other ships to follow.

A second series of full-scale tests were undertaken during the winter of 1976/77. The object of these tests was to demonstrate the commercial application of the air cushion platform, and to accumulate additional data on its capability under operational conditions with commercial type vessels. The technique for the demonstration was to use the commercial tug THUNDER CAPE or the CCGS GRIFFON to push the ACT-100 air cushion icebreaking platform to a vessel requiring a temporary icebreaking assistance. During the trial, the commercial vessel IMPERIAL ST. CLAIR was assisted in this manner. In addition, the ACV was attached to the bow of the ST. CLAIR to demonstrate the feasibility of such an operation. These trials showed a threefold improvement in the icebreaking capability of the combination ship and ACIB over that of the icebreaker operating alone.

In 1979, the Canadian Coast Guard contracted for a purpose designed Air Cushion Icebreaking Bow (ACIB) to be built by Hoverlift Systems Limited (HSL) in Calgary. When Hoverlift Systems were unable to deliver the ACIB to Transport Canada in fully operating condition,

as required by their contract, the Transportation Development Centre (TDC) was tasked by Coast Guard to prepare the craft for testing and carry out initial tests of the design.

In the Fall of 1981, the ACIB was moved from Calgary to Thunder Bay, the site of the earlier ACT-100 trials. The craft was completed and limited tests were carried out late in the 1981/82 winter season. These tests achieved a performance which was, in some respects, similar to that of the earlier icebreaking platform. They also identified a number of design deficiencies which required correction prior to further testing.

In order to complete the evaluation, and to explore the full operating envelope of the ACIB, it was planned to carry out certain essential repairs and modifications to the craft and to conduct a further test program over varying ice thicknesses, using one or more host ships, during the 1982/83 winter season. The proposed plan of action was to select a prime contractor for the evaluation, who would be responsible for the establishment of a test plan, the implementation of the essential repairs and modification of the ACIB, the day-to-day maintenance and operation of the craft, the direction of the trials (in co-operation with TDC and the Canadian Coast Guard), the collection of data, the analysis of test results (including extrapolation of these results to describe an ACIB suitable for use in the Arctic), and the preparation of reports.

The objectives of the 1982/83 trials were:

1. To explore and define, in quantitative terms, the performance parameters of the ACIB.

2. To gain operational experience with the ACIB to the greatest extent practical during the 1982/83 winter season.

These trials may be summarized as follows:

1. A very extensive program of repairs and modifications was carried out and initial, unnotched tests completed by mid-January. That this was possible was due entirely to very mild weather and to the enthusiastic commitment of Vulcan Machinery & Equipment and Rematech Industries to the project. No significant difficulties were encountered except with the hydraulic system control valves and winch brakes and, in general, the design changes, principally in the notch area and to the attachments of the skirt segments, were very successful. Hover testing over land produced the expected heave instability, but the craft performed satisfactorily over water, and the absence of major air leaks and the smooth inflation of the notch segments was apparent.

2. Tests with the tug THUNDER CAPE exceeded expectations. Removal of bumpers and fairing of protrusions on the bow of the tug was satisfactory, and notching was quite straightforward. However, some minor damage was incurred which could be avoided another time. The actual icebreaking, which was performed in 30-35 cm of ice was entirely successful, and a continuous speed of 5.4 knots was achieved. The manoeuvrability (a turning circle of 25 m radius) was exceptional.

3. Tests with the CCGS ALEXANDER HENRY also went very well, no difficulty being experience with notching, and continuous speeds up to 6 knots achieved in ice thicknesses up to 66 cm.

4. During the tests, extensive damage was incurred to skirt segment sole plates. These plates were designed to prevent entry of ice pieces into the segments when travelling in a direction such that the inboard edge of the segment is leading, that is, when the segment can scoop up ice or water. They consist of a piece of material closing the inboard face of each segment, except for a flap at the bottom, which folds over the open, scooping edge of the segment when the flow is outward. They worked satisfactorily

as intended on the aft segments but on the forward sections, where the flaps are trailing in forward motion, the flaps became trapped between ice pieces and the sole plates were damaged or torn off. Some consideration was given to operating without carrying out repairs. However, as the ALEXANDER HENRY was due for a self-refit program, it was decided to modify the sole plates and repair all damage. During tests after this repair work, the port engine fan drive clutch failed catastrophically and had to be replaced.

5. Operational trials with the ALEXANDER HENRY were carried out successfully by a Coast Guard crew who had no difficulty with the operation or handling of the ACIB. The icebreaking performance of the combination was impressive, particularly in terms of the rate at which ice was broken, the elimination of the necessity for ramming, and the reduction in the number and severity of propeller ice strikes. Damage to sole plates recurred during this phase and was attributed to poor bonding and some poor workmanship resulting from rushed work. Subsequent investigation has shown that curing is arrested under freezing conditions, and it is probable that no new bonds were given sufficient time inside the shops to cure properly. In spite of the damage, the ACIB was available and used successfully to break ice as long as it was required.

6. Following the operational trials, the craft was beached on a pad formed from the ballast blocks and decommissioned to a caretaking status pending decisions regarding its future.

The ACIB continued on caretaking status with extensions of the contract until it was terminated finally at the end of October 1983.

Time began to run out on a program for the ACIB during the winter of 1983/84, and it was not until November that TDC was tasked by CCG to arrange a contract for the operational use of the craft. The lead time did not permit going to tender, and, on 12 December 1983, the contract was awarded by Supply & Services Canada to German & Milne

Inc., who had been responsible for the successful program of the previous season (see TP 4666E, "Air Cushion Icebreaking Bow (ACIB) Trials Report 1982/83").

The objectives of the 1983/84 operations were to be as follows:

1. To obtain pertinent data on hardware, performance and operations of the ACIB during the 1983/84 ice management period in Thunder Bay for an adequate assessment of its effectiveness under the following conditions:

   a) At beginning of the winter season;
   b) Under severe winter conditions (cold, wind, snow, etc.);
   c) Icebreaking up to 1 m of ice thickness (design max.).

2. To characterize the performance of the ACIB when it is pushed by a small ship (THUNDER CAPE).

3. To monitor and document the operational performance and the maintainability of the ACIB.

4. To perform all necessary maintenance and minor repairs required for proper functioning.

5. To collaborate with and advise the CCG in operating the ACIB craft and/or to resolve problems.

The report which follows presents a narrative account of the operations, including summaries of the performance parameters measured, observations made, conclusions and recommendations.

1.2 WORK DESCRIPTION

Without going into the detail contained in the contract work statement, the tasks given to the contractor were as follows:

1. Provide a Work Statement.

2. Provide dedicated personnel.
3. Establish and maintain an operational base.
4. Identify and define repairs, material and modifications required.
5. Implement the repairs and modifications.
6. Procure and install monitoring equipment.
7. Carry out all required maintenance during the ice management period.
8. Monitor the budget and maintain records.
9. Monitor all operations, collect data and maintain records.
10. Charter the THUNDER CAPE and make any modifications necessary.
11. Collaborate with CCG and TDC in preparation of the operational plan.
12. After the operations, ensure proper storage of the ACIB.
13. Provide reports.

With the exception of 10 and 11, all these tasks were completed.

In the event no operational plan was prepared and, as will be described later (para 3.1), the use of the THUNDER CAPE was related to another project, the clearing of slips. Unfortunately, by the time clearance for the slip trials was obtained, the THUNDER CAPE had become involved in its normal routine work, and was no longer available.

1.3 MODUS OPERANDI

The very late decision to use the ACIB in the 1983/84 ice management program resulted in the same players being involved, as in the previous year, and their familiarity with the requirements, with procedures and with each other facilitated a quick start. Nevertheless, with a contract date of 12 December 1983 (three days ahead of the expected date), it was quite impossible to have the craft ready for operation by 6 January 1984, as suggested in the original Work Plan, and it was not until 21 February that work was completed.

General policy was handled by a Steering Committee, chaired by Mr. J. E. Laframboise, of TDC, the TDC Project Officer. CCG Headquarters (Mr. M. A. Ball), Central Region (Captain A. Lowe) and the Thunder Bay Sub-Base (Mr. G. Stieh) were represented, and the CCG Project Officer, Captain J. McDonald, Master of the CCGS ALEXANDER HENRY was also a member. Meetings were also attended by the CCG officers seconded to the project, and by representatives of German & Milne Inc. The Work Plan (Appendix "A") was approved by the Committee on 19 January 1984. The Work Description given in the contract indicated that CCG would be in charge and responsible for the operation of the ACIB, with German & Milne collaborating and advising in the operation and being responsible for carrying out the maintenance tasks. In the event the operation was carried out by CCG with German & Milne personnel assisting, and, as in the previous season, German & Milne personnel made all the decisions with regard to engineering and maintenance problems, as well as ensuring that corrective action was taken. If this is to be the pattern for future operations, it is suggested that a CCG engineer officer is not required, and that one deck officer would suffice. This would reduce cost. ACIB handling is quite straightforward, and it does not take long to become familiar with it.

It was accepted by the Contract Authority that German & Milne would sub-contract repair and modification work to companies located in Thunder Bay. Because of the excellent co-operation and response provided during the 1982/83 trials, it did not seem necessary to look further than Vulcan Machinery & Equipment Limited and Rematech Industries, Division of Rubbertex Corporation Limited for help. The same relationship continued during the 1983/84 operations, and it is to the credit of contractor's and sub-contractors' personnel that the tasks were accomplished under pressure and very adverse weather conditions, which will be apparent from the narrative report. A great deal of overtime had to be worked, and the consequences of not being able to provide adequate quality control for a diluted work force had to be faced again. Because work was not done during good weather and with adequate time to do it properly, the cost of the preliminary repairs

and modifications, and of repairs made during the operations was much greater than it might have been. The keenness and dedication of the project personnel can never compensate for lack of planning.

However, the task was carried out successfully, and a number of useful lessons were learned.

2.0 REPAIRS AND MODIFICATIONS

Prior to and during the 1982/83 trials, a number of deficiencies were noted in the trials report, TP 4446E, by German & Milne Inc., and in the report prepared by Mr. J. Hansen of CCG, Central Region.

Several repairs and modifications, identified as most beneficial for the operation and essential for safety, were undertaken in the limited time available prior to the 1983/84 icebreaking season.

Working conditions were extremely severe, with temperatures reaching as low as -34°C accompanied by equally severe wind chill factors. In some instances, welding had to be stopped since welds were cracking due to the high rate of cooling, only 30 cm behind the arc of the welder.

Increased costs were involved, in some instances at least a 50% factor above original estimates, because of climatic conditions, requiring the preheating and controlled cooling of welds to prevent cracking.

Work on the craft came to a temporary halt on the 20th January as the wind chill effect increased. The wind chill factors for the day produced an average temperature of -77°C. The average wind chill temperature for the month of January was -47°C.

Due to the delay caused by inclement weather conditions, and in order to meet the target date for commencement of operations, a large amount of overtime had to be worked by both contractor and sub-contractors.

Cost and efficiency of this type of work could be greatly enhanced by performing the work over the summer lay-up period.

Modifications and repairs are described in detail in the following sub-sections.

2.1 ACIB MODIFICATION/REPAIR ITEM

System: Deck structure.

Equipment:

Purpose: To increase efficiency, and improve structural strength.

Description:

Deck joints in the previous seasons have been a major source of air leaks from the plenum chamber. The joints had been poorly sealed on assembly, and caulking did not prove satisfactory. Doubler plates were fitted on the deck seams and welded.

Achievement:

Total elimination of air leaks from any of the deck seams made a great contribution in terms of retained air, resulting in better cushion pressure.

2.2 ACIB MODIFICATION/REPAIR ITEM

System: Notch

Equipment: Notch segments

Purpose: To minimize further damage to the notch segments.

Description:

The notch segments were all repaired and converted from open sole, with anti-snag flaps, to a closed sole design. It had been desmonstrated in the 1982/83 trials that there was a need to have no loose rubber hanging where there was any possibility of snagging or tearing.

Achievement:

The notch segments continued to incur serious damage over the 1983/84 season. The craft was beached on five occasions and the notch segments were found to be damaged in all instances.

1. Beached 27.02.84 - Tear, 3 m long in the outer face of segment No. 2. Repaired in situ.

2. Beached 09.03.84 - Tear 3 m long in the outer face of segment No. 4. Soles of segment Nos. 4 and 5 extensively damaged. Repaired in situ.

3. Beached 21.03.84 - Tears in the outer face of segment Nos. 3, 4, 4, 6 and 8. Repaired in situ.

4. Beached 24.03.84 - Tears in segment Nos. 4, 5 and 6. Repaired in situ.

5. Beached 29.03.84 - Segment Nos. 2, 4, 5, 6 and 8 damaged. Repaired in situ.

2.2 (Continued . . .)

Damage was partially due to the fact that the notch segment material is so old, and on the point of failure. Skirt material has been exposed to the effects of ultraviolet for the past five years.

Some consideration, however, must be given to the design. The notch being compressed by the hull of the ship is susceptible to damage from ice blocks being up-ended on contact with the ship's stern. There must also be damage incurred due to the skirts being crushed between the ice and the hull of the ship.

2.3 ACIB MODIFICATION/REPAIR ITEM

System: Main skirts

Equipment: Skirt segments

Purpose: To reduce down-time caused by skirt damage.

Description:

All skirt segments were removed from the craft at the end of the 1982/83 season, inspected, and converted to "closed" soles, with the soles being bonded on the inside of the skirt segment.

Achievement:

Initial damage to the skirts in the 1983/84 season was incurred travelling in thin ice, and on beaching it was found that a total of 40 skirts had sustained damage to some extent. This ranged from loose fingers, to completely torn soles, and in one instance a tear vertically up the face of the segment. Repairs were carried out, but damage recurred.

Due to the time factor involved in removal and shipping to a sub-contractor for repairs, it was decided that the forward skirts once damaged should be converted to "open" soles because the "closed" sole modification was evidently not effective in reducing damage.

On further beaching operations, the skirts were inspected and were repaired, or converted to "open" soles, depending on their position around the craft.

Apart from the fact that all skirt material on the craft is badly weathered, it should be noted that the area of the skirt segment which sustains most damage is the sole. Since a number of the segments (23 in all) were converted to the "open" sole type, they sustained no further damage over the season.

Tears in the faces appear to occur at the point where the skirt has been folded and stored, exposed to sunlight during the off season.

2.4 ACIB MODIFICATION/REPAIR ITEM

System: Notch

Equipment: Notch wear apron

Purpose: To increase the life of the notch segments.

Description:

The previous arrangement of a three-piece wear apron was found to be unsatisfactory in that the upper attachments were easily snagged, and pulled loose, and there was not enough protection for the segments at the end nearest the apex of the notch.

A new wear apron was designed and fitted, which consisted of one piece of heavy belting material. The aprons are attached to the crests of Nos. 4 and 5 notch segments, by means of Flexco type belt fasteners and are connected to the spray aprons by means of shackles and D-rings.

Achievement:

The new apron served its purpose very well and damage due to rubbing of the ship's hull on the sidewall of the notch segments was non-existent. There remains, however, the problem of the ship's hull pinching the segments against the notch beams, and thus wearing the segments through, partially from the inside.

2.5 ACIB MODIFICATION/REPAIR ITEM

System: Spray aprons

Equipment: Secondary spray apron

Purpose: To increase safety on deck by minimizing spray and consequent ice build-up.

Description:

The 1982/83 season started with the spray apron fastened up short to reduce the spray escaping from the gap between the apron and the deck edge. This worked well except that ice formed inside and outside at the gap, preventing the escape of air from between the spray apron and the skirt segments, and resulting in porpoising.

Lowering the spray apron, sufficiently to prevent the top from freezing up, stopped the porpoising, but increased the spray onto the deck.

A secondary spray apron, consisting of a flap of about 46 cm in length was fitted over the gap between the primary apron and the deck.

Achievement:

Spray on deck was drastically reduced. Icing up of the deck area was never a serious problem over the 1983/84 season.

It may be of interest that, although this modification was suggested as an original idea by Mr. Markham, he found in subsequent discussion with Mr. H. S. Fowler of NRC, that the principle had already been tried and tested (see An Improved Dust/Spray Skirt for Air Cushion Vehicles, H.S. Fowler and G.S. Bond, NRC LTR Eng 70, Dec 77).

2.6 ACIB MODIFICATION/REPAIR ITEM

System: Notch

Equipment: Top brackets on carousel

Purpose: Increase the strength of the bracket

Description:

Several occurrences of failure were encountered in the 1982/83 season of these brackets. Additional strengthening was installed, i.e. a piece of steel ¼" x 2" was welded to the underside of the top bracket.

Achievement:

No failures in the 1983/84 season.

2.7 ACIB MODIFICATION/REPAIR ITEM

System: Fire protection system

Equipment: Main engine system

Purpose: Increase safety on the ACIB and the fire protection of the main engines.

Description:

The engine cooling system has been modified so that the intake and outlet louvres close automatically when the engine is stopped in an emergency. This will reduce the loss of extinguishing gas, when the fire extinction system is activated.

Outlet louvres have also been increased in area, to permit greater cooling flow through the enclosure, thus eliminating the necessity to open enclosure doors to aid the cooling system.

Achievement:

Very successful modification and a great increase in fire security.

2.8 ACIB MODIFICATION/REPAIR ITEM

System: Winches

Equipment: Port Colbourne fairleads

Purpose: To prevent damage to transit and notching cables.

Description:

The original roller type fairleads having proved unsatisfactory were replaced by four (4) Port Colbourne fairleads, mounted at the deck edge.

Achievement:

The new arrangement for mooring, notching and transit, has greatly increased the ease of handling of the craft. By using various permutations of cable runs, the transit winches are now totally capable of manoeuvring the craft along the wharf, and into suitable positions for notching and beaching. Operations with the cables are now much more efficient, and safer.

2.9 ACIB MODIFICATION/REPAIR ITEM

System: Winches

Equipment: New cables of greater diameter and strength.

Purpose: To increase the pulling power of the transit winches.

Description:

New cables were purchased for the transit winches. Since the operating pressure of the hydraulic system is directly related to the strength of the cable, this allowed the winch operating pressure to be increased to 1500 psi. The new cable is of a design such that an increase in diameter from the original ½" dia. to 7/8" dia. has resulted in a 75% increase in the strength of the cable. The cable drums, however, being grooved to suit the smaller cable, had to be covered with a layer of stainless steel plate to allow the cables to be reefed properly on the drums.

Achievement:

The pulling power of the transit winches has been increased and, combined with the installation of the Port Colbourne fairleads, the craft is now very easily manoeuvred along the wharf, into positions suitable for notching or landing.

2.10 ACIB MODIFICATION/REPAIR ITEM

System: Hydraulic and electrics

Equipment:

Purpose: To remove the obstruction caused by overhead cable trays, in the interests of safety and neatness.

Description:

The original hydraulic system consisted of cross connecting pipes (steel) between the two sets of pumps, run in overhead cable trays, with long flexible hose connections to the valves at each winch. This arrangement was removed, and steel piping was run on deck as near to each winch as possible, with only short lengths of flexible tubing at the connection to the winches, to absorb any vibration. The complete system was covered with removable steel protection plates.

Cables which had originally run in the overhead trays were re-routed on the deck, under the same protection plates.

Achievement:

An improvement in safety during operations such as hoisting the ship boarding ladder, and in personnel safety when boarding the ship. Cables and piping are now very well protected from damage, and the overall appearance of the craft has improved.

2.11 ACIB MODIFICATION/REPAIR ITEM

System: Winches.

Equipment:

Purpose: Increase safety and serviceability.

Description:

The transit winches required moving aft on the craft, a distance of approximately one metre, to allow for a walk space around them, and to reduce the danger of protrusions on the dock damaging the hydraulic tubes.

This was done in conjunction with the locating of the new Port Colbourne fairleads, so that a good all round arrangement of cable handling equipment could be achieved. Plates and tubes were fitted at all winches to protect the hydraulic valves from accidental damage.

Achievement:

Improved arrangement of cable handling in conjunction with the new Port Colbourne fairleads and relocated hydraulic piping, allowing much easier access around both winches, and around the deck perimeter.

2.12 ACIB MODIFICATION/REPAIR ITEM

System: ACIB controls

Equipment: Remote panel

Purpose: To increase safety, ease of operation and efficiency.

Description:

The remote control panel instruments were re-arranged to incorporate instruments in a more logical pattern, in groups of three, in a similar pattern to the engines, i.e. port, centre, starboard.

Each engine's instruments are now easily compared with the next and differences in gauge readings, indicating possible problems, can be spotted at a glance.

Achievement:

The layout of the remote panel is now virtually ideal, and allows even the least experienced of operators to identify problems at a glance, thereby enhancing ease of operation and increasing safety.

The only further modification that would improve the panel would be the replacement of the cushion pressure gauge, which presently reads 0 to 10, with one which reads in inches or centimetres of water.

2.13 ACIB MODIFICATION/REPAIR ITEM

System: Undercraft inspection

Equipment: Lighting for undercraft inspection

Purpose: Increase undercraft visibility for skirt, notch and structural inspections.

Description:

The undercraft lighting was proved to be a success in the 1982/83 season, although not all areas of the underside of the craft were covered by adequate lighting. Four (4) additional underwater lights were installed.

Achievement:

Improved visibility, but there are still deficiencies in the system. Several of the seals on the light units leaked in operation, and lights were at one time totally cut out due to an ice strike on the cable.

2.14 ACIB MODIFICATION/REPAIR ITEM

System: AC electrical system

Equipment: Lighting

Purpose: Increase safety while operating, inspecting, or servicing equipment at night.

Description:

The previous deck lighting arrangement was found to be inadequate for work on deck after dark. Additional lights were installed to light the notch area and the winch positions.

Achievement:

Great improvement in lighting system. Working on the craft at night is now much safer and the notch area especially can be very easily inspected.

2.15 ACIB ESSENTIAL REPAIRS FOR 1984/85 SEASON

If the craft is to operate next season, it is absolutely essential that the skirt system undergo some vigorous maintenance and refurbishment. Skirt material is now 5 years old and has been exposed to the elements since the initial construction of the craft.

Repairs to both skirt and notch segments during the season were essentially "quick fixes" to cut down on the lay-up time during the most productive period of operation.

The complete skirt system should be removed and inspected, over the summer, and all temporary repairs should be made permanent.

It is suggested that the craft should be equipped with one (1) spare straight segment, and one (1) spare corner segment. Sufficient material should be purchased for the manufacture of one (1) notch segment.

A number of skirts, at the forward edges of the craft, having sustained damage in the sole area, were converted to "open sole" type, and sustained no further damage during the remainder of the season.

The ideal conversion seemed to be a reinforcing strip bonded to the open edge of the skirt bottom. The manufacture of additional skirts would provide an opportunity to study various skirt configurations.

3.0 OPERATIONS

3.1 GENERAL

As specified in the Contract and amplified in the approved Work Plan (Appendix "A"), German & Milne was required to obtain pertinent data on hardware, performance and operation of the ACIB during the 1983/84 ice management season under the following conditions:

- o At the beginning of the season;
- o Under severe winter conditions (cold, wind and precipitation);
- o Icebreaking up to 1 m ice thickness (design maximum).

These data were to be obtained with the ACIB used in combination with the CCGS ALEXANDER HENRY and with the tug THUNDER CAPE.

Icebreaking operations with the ACIB could not be performed at the beginning of the winter season because the necessary repairs and modifications to the craft did not commence until 12th December 1983, the awarding date of the Contract, with the work continuing to 21st February 1984.

However, during the period 22nd February to 4th April 1984, the icebreaking capabilities of the ACIB/ALEXANDER HENRY combination were well demonstrated under weather conditions ranging from extremely cold to moderate and in ice thicknesses ranging from 15 to 90 cm. The latter ice thickness was encountered in the slip adjacent to the Manitoba Pool No. 1 elevator during slip tests arranged by the Thunder Bay Harbour Commission. The purpose of these tests was to measure the ice forces on the piers during entry of the ALEXANDER HENRY alone and in combination with the ACIB. The ice force measurements were made by ARCTEC Canada Ltd. under contract with Thunder Bay Ice Management Task Force, with the findings being reported separately.

Regarding the performance demonstration with the ACIB/THUNDER CAPE combination, this was not accomplished. The particular requirement was to demonstrate the ACIB/THUNDER CAPE icebreaking capability in 1 m

ice. During the 1983/84 season, ice of this thickness in the vicinity of Thunder Bay occurred only in the slips adjacent to the elevators and clearances and waivers were required from the elevator owners before such tests could be undertaken. By the time such clearances were obtained, the harbour was open to navigation, the THUNDER CAPE was on continuous call to move ships in the harbour area and could not be released for the test demonstration. Accordingly, the requirement for the tests during the current season was cancelled by TDC.

This section of the report outlines the icebreaking performance characteristics of the ACIB/ALEXANDER HENRY combination and the means employed to obtain performance data.

3.2 TEST INSTRUMENTATION

3.2.1 Requirement

The following performance parameters were to be measured during icebreaking operations:

ACIB:

- Engine RPM
- Cushion pressure
- Hover height
- Trim angles
- Fuel consumption
- Weight
- Video documentation of icebreaking dynamics above and below deck

Ship:

- Engine/Shaft RPM
- Speed
- Fuel consumption

Ice Conditions:

- o Thickness
- o Path width
- o Piece size
- o Water temperatures
- o Ice temperatures

Environmental Conditions:

- o Air temperature
- o Wind velocity
- o Barometric pressure

3.2.2 ACIB Instrumentation

3.2.2.1 ENGINE RPM

The existing tachometer gauges located in the ACIB control room were used to obtain engine RPM data. These were calibrated against a hand-held electronic tachometer which was used to measure engine drive shaft RPM directly.

3.2.2.2 CUSHION PRESSURE

The available U-tube water manometer was installed in the control room to obtain cushion pressure data. This unit was used in preference to the instrument panel cushion pressure gauge because of its greater precision and damping.

3.2.2.3 HOVER HEIGHT

This was obtained by employing a surveyor's tape suspended from a plank mounted on the starboard side of the ACIB in line with the transverse axis.

3.2.2.4 TRIM ANGLES

These were obtained with an inclinometer calibrated in percent of 45°. Fore and aft and transverse measurements were taken at a spot marked on the centre buoyancy tank.

3.2.2.5 FUEL CONSUMPTION

This was determined by recording the total amount of fuel obtained from the ALEXANDER HENRY and from the local fuel dealer. This was equated to engine hours of operation and RPM.

3.2.2.6 WEIGHT

The weight and centre of gravity of the ACIB in its various configurations were determined by recording the weight and location of all added items including equipment, ballast and fuel and calculating the incremental change to the known basic weight and centre of gravity.

3.2.2.7 VIDEO DOCUMENTATION

An underdeck video camera was installed to obtain information on icebreaking action and segment condition. The installation consisted of a video camera mounted in a cylindrical waterproof container with a transparent panel in one end. Interior heaters were provided to reduce the effects of condensation and icing of the window. The camera container was installed in a mounting bracket which also housed two Halogen automobile headlights. This assembly was attached to a 5 cm pipe fitted with a flexible joint to minimize damage to the camera from ice strikes. The unit was suspended through a sealed hatch in the deck and it was raised and lowered by means of a pulley and winch device. The camera video output was fed to a VCR located in the ALEXANDER HENRY chart room and in turn to a 23 cm TV monitor also located in the chart room. Rotation of the video camera was achieved

by manually turning the support tube. Additional underdeck lighting was provided by the underwater lights described in paragraph 2.13.

Above-deck video documentation was obtained with a rented colour video camera and portable VCR.

3.2.3 Ship Instrumentation

3.2.3.1 ENGINE/SHAFT RPM

The rotational speeds of the ALEXANDER HENRY's engines and propeller shafts were measured with an HP3497A Data Acquisition System and an HP85F computer. The data signal was picked off from the ship's tachometer circuits which operated the RPM meters in the engine room. The data was displayed on a CRT as a progressive plot which was cleared and printed out on a strip chart every 12 minutes.

This instrumentation was out of service during the period 23 February 1984 to 16 March 1984 due to a malfunction in the HP3497A Data Acquisition System. During that period, shaft RPM was read from the tachometer gauges in the ALEXANDER HENRY's bridge. The ship's tachometers were checked with an electronic tachometer taking measurements directly from the shaft and found to be accurate in the speed range of interest - 100 to 230 RPM.

3.2.3.2 SPEED

Ship's speed was determined by means of a video camera mounted in such a manner as to view the passage of ice along the side of the ship from a location as high above the waterline as practical. The video output of the camera was fed to a TV monitor which had a time/date presentation superimposed on its screen from a time/date generator. Speed was determined by measuring the time of passage of ice between calibration marks on the TV monitor screen. These marks were obtained by viewing markers at the ice level of a known distance apart. The location of the camera on the ALEXANDER HENRY is shown in Figure 3. The video signal on the TV monitor was recorded on a VCR for post-test

analysis. Periodic checks of the speeds obtained with the video camera were made against speed determinations made with the ship's navigation equipment.

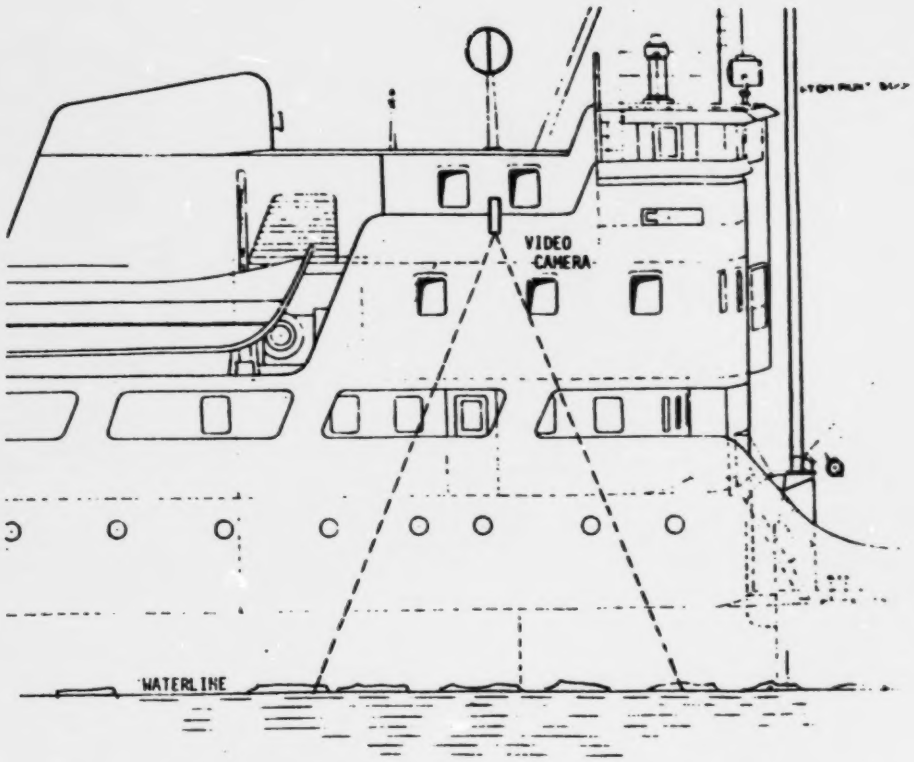


FIGURE 3: VIDEO CAMERA INSTALLATION FOR SPEED MEASUREMENTS

3.2.3.3 FUEL CONSUMPTION

The ALEXANDER HENRY's fuel consumption was determined by recording the fuel flow meter readings at the beginning and end of the day's operation on each of 11 days of representative operations.

3.2.4 Ice Conditions

3.2.4.1 ICE THICKNESS

Ice thickness measurements were made during operations with the ALEXANDER HENRY with a pike pole fitted with a rod marked in 15 cm intervals.

3.2.4.2 PATH WIDTH

This was determined by estimating the distance beyond the beam of the ACIB that ice was being broken.

3.2.4.3 PIECE SIZE

This determination was made by scaling characteristic pieces as seen in the velocity measuring video camera coverage of the ice passing the side of the ship.

3.2.4.4 WATER TEMPERATURES

These measurements were made by the ALEXANDER HENRY crew as a matter of routine and on request for trials data. The equipment employed was a small diameter plastic bucket with a thermometer mounted centrally in it. The bucket and thermometer were dropped overboard on a lanyard and immersed in the water a few feet below the ice level.

3.2.4.5 ICE TEMPERATURES

Ice temperature measurements were made with an Omega Model 4501-1H digital thermometer and probe. The probe was attached to a long pole. Measurements were taken when the ship was stopped by pressing the probe against the surface of a conveniently oriented slab of broken ice.

3.2.5 Environmental Data

Air temperature, wind velocity and barometric pressure data were obtained from the ship's instrumentation and from the Thunder Bay weather office. (Appendix "B").

3.3 ICEBREAKING PERFORMANCE

3.3.1 GENERAL

The operations performed by the ACIB/ALEXANDER HENRY combination during the 1983/84 ice management season are summarized in Figure 4 and characteristic performance data are summarized in Figure 5. A narrative of salient observations concerning the 16 days of operational icebreaking follows.

The ice conditions encountered during the season varied from hard, snow-free, previously unbroken to snow covered, broken and refrozen to decaying. For the purpose of the narrative, the various day's operations are grouped according to the predominant ice characteristics encountered. The slip tests which were performed on 23rd March 1984 are treated separately.

3.3.2 OPERATIONS IN HARD, PREDOMINANTLY SMOOTH ICE

The ice conditions encountered during operations on 22 and 23 February and 1, 6, 7 and 8 March 1984 were hard, predominantly smooth with minimal snow cover. The ice on 22/23 February and 1 March was essentially snow-free. However, there was a 3.4 cm snowfall on 5 March but this did not appear to materially affect the ACIB/ALEXANDER HENRY performance except for fuel consumption, as noted later in this section. The tracks made on the first three days of this series of operations were through previously unbroken ice. However, on the last 3 days, an increasing proportion of the tracks were through previously broken and refrozen ice.

The purpose of these operations was to open and maintain tracks from the harbour entrances to open water off the Welcome Islands. The tracks achieved are shown in Figure 8.

The ice thicknesses encountered for the majority of the distance travelled was 60 cm with 75 cm being encountered in a ridge and 40 cm near open water. During part of the operations on 8 March, 15 cm ice

ACIB/ALEXANDER HENRY, 1983/84 PROGRAM
OPERATIONS SUMMARY

DATE	OPERATION	TIMES (h:m)			DISTANCE (n.m.)	AV. SPEED (k)
		Steamed	Stopped	Underway		
22 Feb. 84	Shakedown operation.	5:40	0:53	4:47	12.5	2.6
23 Feb. 84	Icebreaking inside main entrance and out to open water.	4:40	0:48	3:52	13.5	3.5
28 Feb. 84	Icebreaking - main entrance and north entrance.	4:10	0:32	3:38	10.5	3.1
29 Feb. 84	Widen tracks for movement of Algolake.	6:12	1:07	5:05	12.5	2.4
1 Mar. 84	Out to open water and return. Airborne cine.	5:15	0:38	4:37	15.0	3.2
2 Mar. 84	Re-open tracks for movement of Algolake.	6:58	1:04	5:54	16.0	3.0
3 Mar. 84	Escort Algolake in tow. Airborne cine.	7:18	1:10	6:08	12.0	1.9
6 Mar. 84	Icebreaking out to open water.	4:35	0:16	4:19	16.0	3.7
7 Mar. 84	Icebreaking out to open water.	5:00	0:13	4:47	16.0	3.3
8 Mar. 84	Out to Welcome Island, into Mission River, around Welcome Island.	6:08	0:21	5:47	28.0	4.7
20/21 Mar.84	Preliminary slip test and 72-hour trials.	16:28	5:25	11:03	24.0	2.2
23 Mar. 84	Slip test and icebreaking between south and main entrances.	6:20	0:20	6:00	10.0	1.7
27 Mar. 84	Icebreaking out to open water.	9:43	0:43	9:00	20.5	2.3
28 Mar. 84	Icebreaking in the harbour area.	8:28	0:27	8:01	18.4	2.3
3 Apr. 84	Track widening inside and outside of the breakwater. Airborne cine	7:20	0:30	6:50	17.5	2.6
4 Apr. 84	Operations in decaying ice. Video coverage from helicopter.	7:30	2:20	5:10	20.0	3.9
		111:45	**16:47**	**94:58**	**262.4**	

FIGURE 4: OPERATIONS SUMMARY

DATE 1984	ICE			SHIP		ACIB						PAIN		TEMPS (°C)		
	Thickness (cm)	Snow Cover (cm)	Condition	Shaft RPM P/S	Speed (k)	Weight (t)	Eng. RPM	Cush. Press (cmH_2O)	Hover Height (m)	Trim (°) F/A	Trim (°) P/S	Width (m)	Piece Size (m)	Air	Water	Ice
22 Feb.	50	Clear	Hard/	200/205	2.8	212.7	1600	66	3.47	+1.3	+1.0	26	2.5 x 3.0	+3	+2	-1
	60		Smooth	230/235	6.0	212.7	1600	69	3.66	+1.7	+1.0	32	2.0 x 2.5			
23 Feb.	50	Clear	Smooth	165/170	2.0	212.7	1600	66	3.32	+1.7	+1.0	26	2.5 x 3.0	+3	+2	-1
	60		Smooth	235/240	6.2	203.7	1600	71	3.69	+1.3	+1.0	30	2.0 x 2.5			
28 Feb.	60	Clear	Broken	200/215	4.0	212.7	1600	66	3.38	+1.7	+1.0	29	2.0 x 2.5	-8	+2	-2
	60		Smooth	200/215	4.0	203.7	1800	66	3.50	+1.3	+1.5	30	2.0 x 2.5			
29 Feb.	60	Clear	Broken	--	-	203.7	1800 (2 eng.)	66	3.44	+1.3	+1.5	-	--	-12	-	-
1 Mar.	60	Clear	Smooth	220/230	4.0	203.7	1800 (2 eng.)	67	3.60	+1.3	+1.5	29	2.0 x 2.0	-8	+2	-1
2 Mar.	60	Clear	Broken	220/230	6.0	203.7	1800	65	3.26	+1.3	+1.5	27	1.5 x 1.5	-5	+2	-1
	60		Smooth	220/230	5.6	203.7	(2 eng.)	71	3.38	+1.3	+1.5	31	2.0 x 2.5			
3 Mar.	60	Clear	Smooth	210/225	5.6	203.7	1800	69	3.44	+1.3	+1.5	29	2.0 x 2.5	-12	+2	-2
			Broken	200/220	5.5	203.7	(2 eng.)	66	3.32	+1.3	+1.5	27	1.5 x 1.5			
6 Mar.	50	Patches/	Smooth	200/210	4.2	203.7	1600	74	3.63	+1.7	0	29	2.0 x 2.5	-16	+1	-7
	45	5 to 10	Broken	220/240	6.0	203.7	1600	71	3.44	+1.7	0	27	1.5 x 1.5			
	55		Smooth	220/240	5.7	203.7	1600	74	3.60	+2.0	0	31	2.0 x 2.5			
7 Mar.	60	Patches	Smooth	200/215	4.0	203.7	1600	69	3.56	+2.0	0	29	2.0 x 2.5	-16	+1	-6
		5 to 10	Smooth	210/225	5.2	203.7	1600	72	3.50	+2.0	0	31	2.0 x 2.5			
8 Mar.	60	Patches	Broken	200/205	3.8	203.7	1600	69	3.29	+1.7	0	27	2.0 x 2.5	-15	+1	-10
	60	5 to 10	Smooth	210/230	5.5	203.7	1600	74	3.56	+1.7	0	31	2.0 x 2.5			
	15		Smooth	200/210	4.4	203.7	1600	FLUCTUATING			0	35	0.6			
	15		Smooth	150/170	3.8	203.7	1600	66	-	-	0	35	0.6			
	15		Broken	200/210	5.6	203.7	1600	FLUCTUATING			0	-	--			
	60		Broken	200/210	3.8	203.7	1600	67	3.14	-	-	27	2.5 x 3.0			
20/21 Mar.	70	15	Soft/	Dead Slow	Halted	203.7	1600	69	3.50	Heave		Not Broken		+1	+1	-2
	50		Smooth	200/220	4.2	203.7	1600	72	3.69	+2.0	0	27	1.5 x 2.0			
	50		Broken	200/220	4.7	203.7	1600	69	3.50	+2.0	0	27	1.5 x 1.5			
	20		Smooth	220/230	6.0	203.7	1600	72	3.56	+2.0	0	30	1.0 x 1.0			
	60		Smooth	220/230	Halted	203.7	1600	66	3.41	+2.0	0	Not Broken				
23 Mar.	90	10 Froz.	Smooth	Dead Slow	1.0	281.0	1800	90	3.00	+2.5	0	32	1.5 x 2.0	-3	+1	-6
	60		Smooth	210/220	3.0	281.0	1800	86	3.26	+2.5	0	29	3.0 x 3.5			
	75		Smooth	190/210	2.0	281.0	1800	86	3.20	+2.5	0	33	4.5 x 6.0			
27 Mar.	60	5 Frozen	Smooth	210/220	4.7	222.0	1800	77	3.84	+2.5	+1.0	29	2.5 x 3.0	-3	+1	-2
	70		Smooth	170/190	Halted	222.0	1800	76	3.66	+2.5	+1.0	Not Broken				
	70		Smooth	220/230	3.5	222.0	1800	79	3.84	+2.5	+1.0	29	5.0 x 6.0			
	75		Smooth	220/230	Halted	222.0	1800	77	3.75	+2.5	+1.0					
28 Mar.	60	5 Frozen	Smooth	200/220	4.0	212.9	1600	70	3.41	+2.0	+1.0	29	2.0 x 2.0	-5	+1	-2
	60		Broken	200/220	5.0	212.9	1600	66	3.32	+2.0	+1.0	29	1.5 x 1.5			
	65		Smooth	200/220	Halted	212.9	1600	66	3.20	+2.0	+1.0	Not Broken				
3 Apr.	50	Clear	Decaying/ Smooth	190/200	4.0	232.0	1600	76	3.35	+1.5	+0.5	30	3.5 x 4.5	+3	+2	0
4 Apr.	60	Clear	Smooth	225/230	5.0	232.0	1600	80	3.60	+1.5	+0.5	32	3.5 x 4.5	+5	+2	0
	60		Broken	225/230	6.0	232.0	1600	79	3.47	+1.5	+0.5	29	1.5 x 1.5			

NOTE: Trim Angles: (+) Bow up, starboard up.

FIGURE 5: ACIB/ALEXANDER HENRY PERFORMANCE DATA

was encountered in the Mission River. These operations in thin ice are covered separately.

The operations covered in this section constitute what is considered to be the most effective utilization of the icebreaking capabilities of an air cushion vehicle.

For these operations, the ACIB was ballasted to an all-up weight of 203.7 t, exclusive of trim ballast. This weight was achieved with four concrete ballast blocks of approximately 4.0 t each. With the ACIB's main engines operating at 1600 RPM, a cushion pressure which averaged 70 cm water gauge was obtained. This cushion pressure was found to be optimum for all of the ice conditions encountered except for the thin ice.

During operations on 1 March, the ACIB was operated on two engines as a consequence of a clutch failure on the port engine which had occurred on 28 February. The circumstances pertaining to this situation are covered elsewhere in this report. For the operations on 1 March, the starboard and centre engines were operated at 1800 RPM giving a cushion pressure of 67 cm water which was adequate for the ice conditions encountered. The only performance characteristic that was altered by operating on two engines rather than three was an increase of 0.5° starboard side up change in attitude.

On 5 March, a new clutch was installed and succeeding operations were performed with three engines operating.

Throughout this series of operations, speeds ranged from 2.0 to 6.0 knots. The correlation between speed and path width, piece size, cushion pressure, hover height and trim angles which were noted in the 1982/83 trials were again observed. The path width increased from 26 m at 2 knots to approximately 32 m at 6 knots. Piece size ranged from 3 m at 2 knots to 2 m at 6 knots. Over smooth, unbroken ice, the cushion pressure increased from 66 cm to 69 cm on the average as speed increased. This was accompanied by an increase in hover height of 0.2

m. The trim angle change was essentially the same as observed during the 1982/83 trials, that is, a 0.5° increase in nose up attitude as speed was increased from 2 to 6 knots.

Of greater operational significance, however, is the marked increase, with increased speed, in the turbulence of the ice pieces as they pass through the ACIB notch area. At speeds up to 4 knots the flow of ice through the notch area is relatively smooth. However, as the speed is increased to 6 knots, the action becomes violent with ice pieces emerging on edge with up to 50% of their volume protruding above the waterline. This action is extremely hard on the notch segments, particularly to those adjacent to the hull of the ship. This was evidenced by damage which occurred to these notch segments during operations on 23 February.

In this instance, excessive spray from the notch area of the ACIB was noted. However, this in itself was not sufficient cause to terminate the operation. Later in the day, it was observed that the spray apron retaining cable had pulled out of its retaining pocket on the port side, aft section of the spray apron. It was, therefore, decided to beach the craft for repairs to the cable pocket and for an inspection of the notch segments and skirt segments. The inspection revealed that the sole pieces of notch segments No. 4 and 5 were badly torn as shown in Figures 6 & 7 and that there was a 0.3 m tear in the lower outboard section of segment No. 2.

A more detailed report on the damage which occurred on this and other occasions is contained in Appendix "C" together with a sketch showing the skirt and notch segment numbering scheme.

Necessary repairs were made to the notch segments and spray apron cable pocket on 25 and 26 February and the craft launched on 27 February.

FIGURE 6: DAMAGED SOLE OF NOTCH SEGMENT No. 4

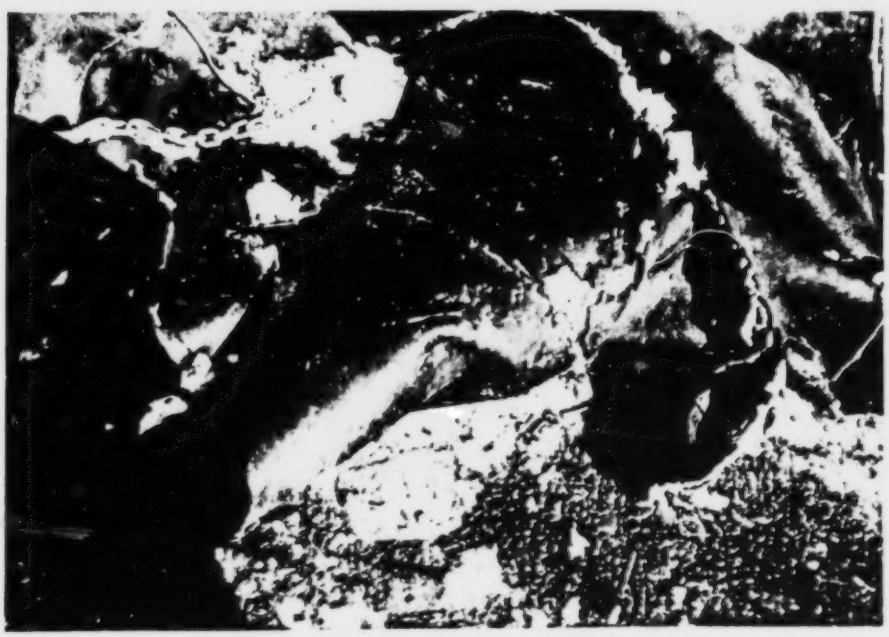


FIGURE 7: TEAR IN NOTCH SEGMENT No. 5

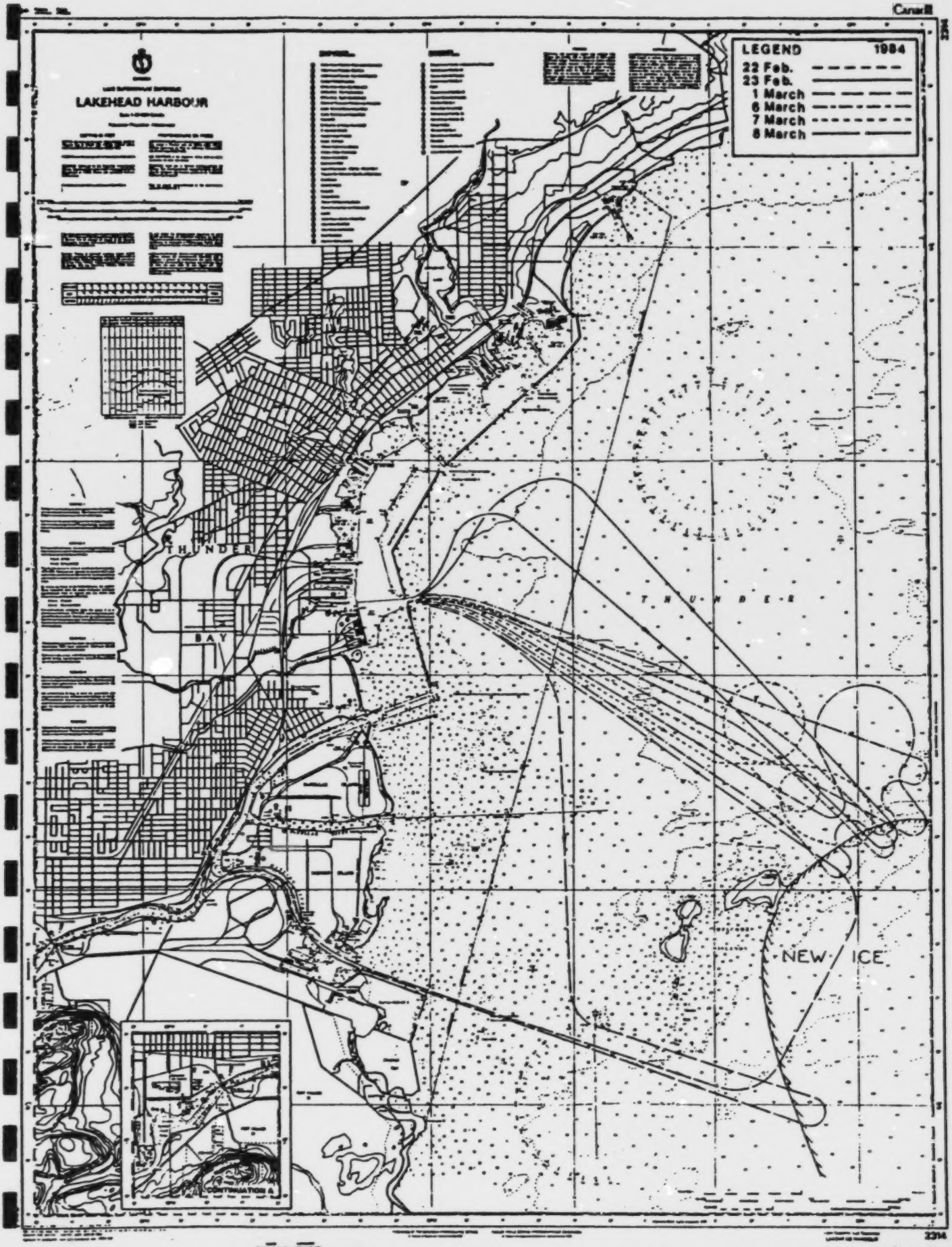

LAKEHEAD HARBOUR
LEGEND 1984
22 Feb.
23 Feb.
1 March
6 March
7 March
8 March
THUNDER
BAY
THUNDER
NEW ICE
CONFIRMATION 6
2314

FIGURE 8

It should be appreciated that there is a gap of some 3 m between the tip of the notch segments and the spray apron. In consequence, ice pieces can surface in this gap and catch the bottom of the apron causing the sort of damage encountered. It is surprising that this has not happened more frequently.

During operations on 1 March, turning radius performance was measured over open water and through 40 cm ice. Over open water, a turning radius of 0.2 km with the rudder hard over and both engines operating at 200 RPM was achieved. Under the same conditions, in 40 cm ice, the turning radius was 0.9 km.

These operations also showed some correlation between fuel consumption and ice surface roughness, Figure 5 refers. For the 2-day period, 23 February and 1 March, the average fuel consumption was 261 litres/hr or 36.1 litres/km. For the 2-day period 6 and 7 March, the average consumption was 314 litres/hr or 49.5 litres/km. The ice surface encountered on the first two days was predominantly smooth and snow-free, whereas on the last two days, approximately 50% of the ice traversed was previously broken and covered with an accumulation of 5 cm of snow which had localized in patches.

3.3.3 Operations In Thin Ice

Part of the operations on 8 March entailed icebreaking in the Mission River. Rather unexpectedly, an ice thickness of only 15 cm was encountered. At the time, the ACIB/ALEXANDER HENRY was proceeding at a speed of 4.4 knots. With a cushion pressure of 74 cm, the ice 6 to 10 m ahead and to the sides of the craft was rupturing violently with a consequent fluctuation of cushion pressure and hover height. This action coupled with the speed of travel resulted in a violent porpoising action which is characteristic of operations with cushion pressures considerably in excess of the thickness of ice to be broken.

At the request of the ACIB Chief Engineer, the speed was reduced to minimize the porpoising and the possibility of damage to skirt segments from the sharp shards of ice which were entering the bow area on edge. Although no extensive damage was observed at that time, undoubtedly damage to some degree had occurred.

On the return journey down the Mission River over the previously broken ice, the speed gradually built up to 5.6 knots. At this point, jets of spray were observed issuing from the skirts in the bow area to the extent that 15 cm of ice built up on the forward deck structure in a period of 15 minutes, and the inlet screen on the centre engine fan was almost totally iced over. Again, it was necessary to reduce the speed to minimize the effect of the spray blowing back over the ACIB from the speed of motion and to reduce the chance of further damage to the skirts. From the underdeck video camera coverage and other observations, it was concluded that at least two skirts in the forward section and one in the port side aft section were badly torn.

As a consequence of this damage, the decision was made to return to base and beach the ACIB for inspection and repair. For the return journey, the speed was kept below 4 knots. Despite the apparent extensive damage to the skirt segments, the cushion pressure had only dropped from 74 to 67 cm and the hover height from 3.5 to 3.1 m.

This situation demonstrated the need for some form of liquid ballast whereby the craft's weight and consequent cushion pressure could be adjusted during the progress of an operation to accommodate the various ice thicknesses that might be encountered.

The inspection of the craft revealed that extensive damage had been done to the skirt segments in the bow area and the port side aft area, as well as to notch segment Nos. 4 and 5. The damage and wear had undoubtedly been cumulative over the period 28 February to 8 March, however, there was no doubt that the particularly serious tears in the two skirts in the bow area had resulted from the operations in thin ice.

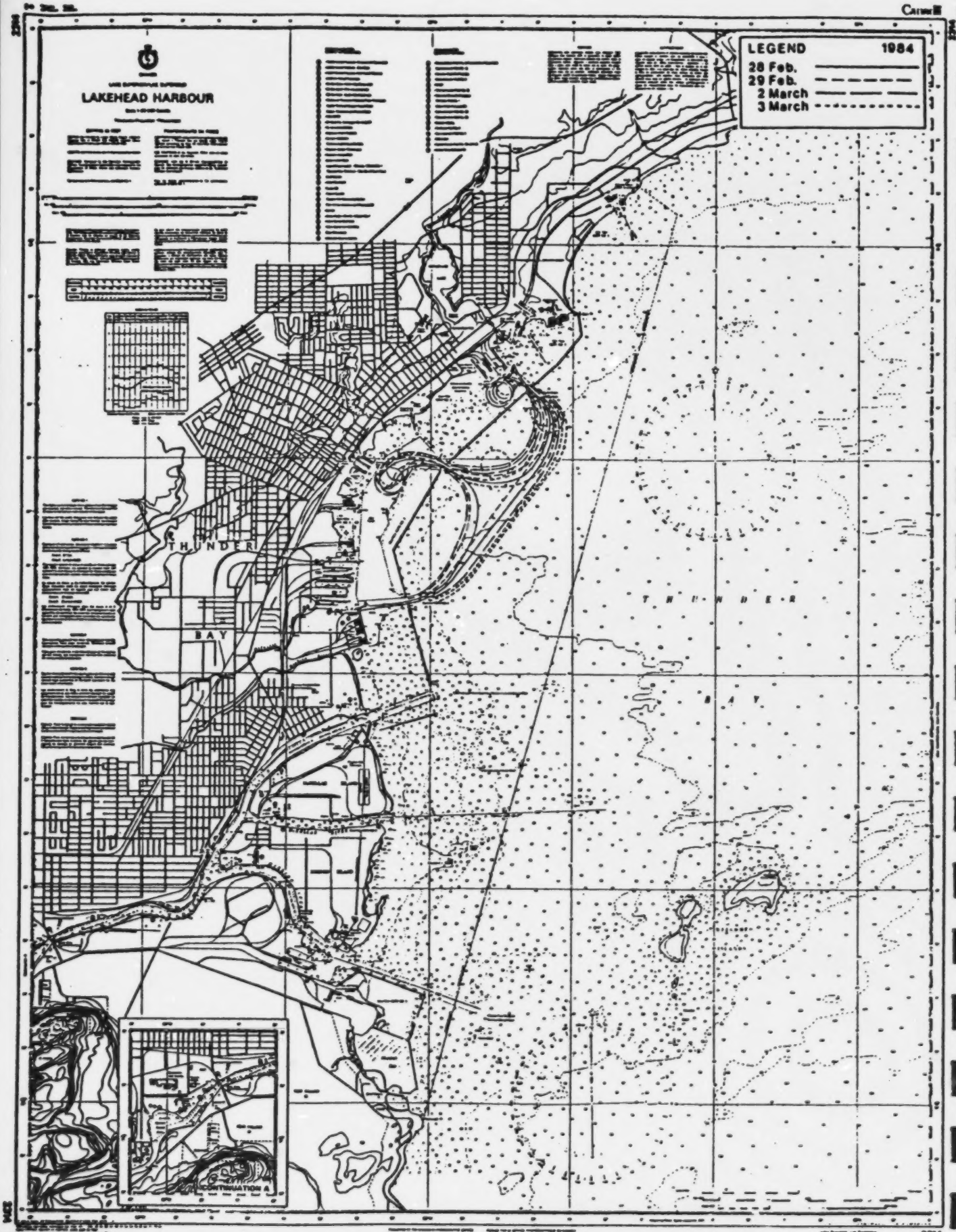

LAKEHEAD HARBOUR
LEGEND 1984
28 Feb.
29 Feb.
2 March
3 March
THUNDER
BAY
THUNDER
BAY
CONTINUATION A

FIGURE 9

The damage entailed the removal of 35 skirt segments for repair at the sub-contractor's shop and the in situ repair of skirts and the two damaged notch segments. The beaching, repair and launching activities required 8 days of intensive activity on the part of the sub-contractor staff and the ACIB crew. The craft was launched and available for further operations on 19 March.

3.3.4 Operations in Previously Broken Ice

The objective of the operations performed on 28/29 February and 2/3 March was to open and maintain tracks for the movement of the freighter ALGOLAKE from the DDS wharf, opposite the main entrance of the breakwater, to the Portship's dockyard inside the north entrance. The tracks made on these days are shown in Figure 9.

On 28 February, the tracks from the south entrance to the main entrance and north entrance were re-opened and manoeuvring areas inside the main and north entrances broken out. Midway through the operations on this day, the ACIB port main engine clutch failed catastrophically, due to prolonged overheating which resulted in the disintegration of the clutch pads and the melting of the aluminum centrifugal force blocks. Since acceptable performance could be achieved on two engines, the decision was made to continue with the opening of tracks for the movement of the ALGOLAKE. In order to provide the necessary degree of safety when operating on two engines, remote control of the ACIB from the ship's bridge was transferred to local control aboard the craft to ensure rapid response in case of malfunction of either of the two operating engines.

Icebreaking operations continued on 29 February as efforts to procure a replacement clutch were pursued. On this day, the ACIB/ ALEXANDER HENRY made tracks for the tug DONALD MAC to proceed from the dockyard wharf to the DDS wharf where it broke ice around the ALGOLAKE. Additionally, the ACIB/ALEXANDER HENRY maintained and widened the tracks for the movement of the ALGOLAKE.

When it was determined that a replacement clutch could not be obtained before 5 March, the decision was made to continue to support the movement of the ALGOLAKE, which was then set for 3 March, with the ACIB operating on two engines. Accordingly, tracks were maintained and widened on 2 March and the movement of the ALGOLAKE supported on 3 March.

On that date, the ACIB/ALEXANDER HENRY led the tugs THUNDER CAPE and DONALD MAC from the Portships' dockyard to the DDS wharf, where they manoeuvred the ALGOLAKE away from the wharf and towed it to the dockyard via the main and north entrances. The ACIB/ALEXANDER HENRY remained in attendance throughout this operation.

Except for the widening of tracks, all of these operations were performed in previously broken ice. The ice encountered during the first day's operation had for the most part been broken earlier in the season and refrozen. It was characteristically 60 cm thick with a 5 cm layer of frozen snow. In maintaining the tracks that had been broken on the first day's operation, the broken pieces were frozen in with 10 to 15 cm of new ice. In widening the tracks, both undisturbed and previously broken and refrozen ice were encountered.

Throughout these operations, the ACIB's all-up weight remained at 203.7 t. The cushion pressure achieved prior to the clutch failure with all three engines operating at 1600 RPM was 66 cm. After the clutch failure with two engines operating at 1800 RPM, the same cushion pressure was achieved.

Cushion pressure and hover height were markedly affected by surface roughness of the ice. When passing from rough, previously broken ice to smooth unbroken ice, the cushion pressure increased by as much as 3.8 cm and the hover height by 0.15 m. Several opportunities for making these measurements occurred during track widening as the craft passed back and forth over broken and unbroken ice.

During the longer runs outside the breakwater, speeds of 4.0 to 5.6 knots were achieved at ship's engine speeds of 200/210 to 220/230 RPM respectively. It was felt by the ACIB crew that speeds in excess of 4 knots over broken ice would accelerate skirt damage and wear. Accordingly, the request was made that speed be limited to 4 knots. For the most part, this limitation was observed.

Numerous turning manoeuvres were made in the basins inside the north and main entrances to prepare the areas for the movement of the ALGOLAKE. Initially, it was necessary to perform one or more backing manoeuvres to complete a 180° turn in the 0.42 km width of the cleared channels. However, as these operations proceeded and the ice was broken into progressively smaller pieces, the turning radius of the ACIB/ALEXANDER HENRY combination approached that which could be achieved in open water (i.e. 0.2 km) and the combination could complete a turn in the space available without backing.

The fuel consumption was measured on three of the four days of this series of operations. The average consumption was 245 litres/hr or 51.3 litres/km. The consumption per hour is consistent with that recorded for the smooth ice series, but the consumption per kilometer travelled is considerably higher due to the number of manoeuvres involved and the lower average speed.

3.3.5 Operations in Resilient Ice

On 20 March following extensive repairs to the ACIB skirts and notch segments, icebreaking operations with the ACIB/ALEXANDER HENRY resumed. The resumption of operations coincided with the onset of moderating temperatures in the Thunder Bay area. On that date, the temperature rose above the freezing level, and a trace of rain and 2.5 cm of wet snow fell. With the moderating temperatures, the breaking characteristics of the ice changed markedly. The suddenness of the change was not anticipated and the ACIB was ballasted to the same all-up weight employed for the earlier operations. Whereas the 71 cm cushion pressure achieved with a weight of 203.7 t was adequate to

break the 60 cm brittle ice encountered earlier, it proved to be marginally adequate for the more resilient ice that prevailed on 20 March.

The plan of operations for the period commencing 20 March included an extended operation of up to 72 hours duration and tests in the slip adjacent to the Manitoba Pool No. 1 grain elevators. A short time prior to the commencement of the extended operation, the necessary clearances for the slip tests were received by the Master of the ALEXANDER HENRY. Although the ACIB was not adequately ballasted to break the 90 cm ice that existed in the slip, nevertheless an exploratory test to determine the forces that would be imposed on the piers as the ACIB/ALEXANDER HENRY combination approached the entrance of the slip was made in conjunction with the extended operation. It was planned that the definitive test would be made following the extended operation, when the ACIB would be fully ballasted.

Unfortunately, the extended test had to be terminated after 17 hours as a consequence of marginal cushion pressure for the ice conditions encountered, and the progressive deterioration of the condition of the ACIB notch segments. However, a very informative demonstration of the effects of resilient ice on icebreaking performance was obtained.

During the period 1600 hours on 20 March to 0610 hours on 21 March, with 4½ hours down-time resulting from a stack fire aboard the ALEXANDER HENRY, a distance of 45 km was covered in ice that ranged in thickness from 15 cm off the Welcome Islands, where new ice had formed, to 65 cm in the vicinity of the harbour breakwater. Moderate drifting of the 5 cm of snow that fell on 15 March, plus the current snowfall of 2.5 cm, resulted in snow cover that varied in thickness from 2.5 to 25 cm. The ice conditions encountered varied from unbroken to previously broken and refrozen in about a one-to-one ratio. The air temperature for most of the operational period was above freezing at +1°C. Ice surface temperature measured -2°C. The tracks made during the 20/21 March operation are shown in Figure 10.

The widening of tracks and the breaking of previously broken and partially refrozen ice posed little difficulty for the ACIB/ALEXANDER HENRY as did ice of thicknesses less than 50 cm. However, previously unbroken ice 60 cm thick brought the combination to a halt several times. On such occasions, the ACIB rested on a dish-shaped depression in the ice that extended for 20 to 30 m beyond its perimeter. The boundaries of the depression were clearly defined by the water that flowed into it. On backing away, the ice slowly rebounded to its original level with little or no evidence of cracking. It was evident that cushion pressures considerably in excess of the nominal 10% greater than ice thickness would be required to break ice of this nature.

The effects of snow cover on speed was also observed during the operation. On passing from areas with little snow cover, the speed dropped from 5.8 knots to 4.6 knots, with the ALEXANDER HENRY engine speeds remaining constant at 220/240 RPM.

It was also noted that engine speeds of 170/180 RPM could maintain a speed of 4 knots over essentially snow-free areas, but could barely maintain forward progress over areas with 25 cm of snow cover. On occasions where the ACIB/ALEXANDER HENRY came to a halt, the snow plowing effect of the ACIB was noted. Whereas the escaping air would blow dry snow away from the bow area of the craft, it did not have the same effect on the wet snow that prevailed at this time, and it piled up ahead of the skirts.

During the latter stages of the operation, a marked increase in the amount of spray issuing from the notch area occurred. This was accompanied by violent flapping of notch segment No. 8 against the adjacent notch wall. These conditions plus the attendant decrease in cushion pressure from the initial level of 72 cm to 64 cm clearly indicated that extensive damage to the notch segment had occurred. Consequently, the decision was made to terminate the operation and beach the craft for inspection and repairs. The damage was attributed

in part to speeds in excess of 4 knots and in part to the generally poor condition of the notch segments.

As there was a need to have the ACIB back in operation for use in the slip tests as soon as possible, the repair operation was carried out with the utmost dispatch. The beaching and inspection was completed by 1200 on 21 March, the repairs by 0800 on 22 March, the launching by 1030 on 22 March and the ballasting for the slip tests by 1500 on 22 March. On the following day, 23 March, the slip tests were performed.

3.3.6 Icebreaking In Manitoba Pool No. 1 Slip

Following the post-repair launching of the ACIB on 22 March, the craft was ballasted for the icebreaking tests in the slip adjacent to Manitoba Pool No. 1. It had been learned from the Port Manager that the ice thickness in the inner area of the slip was 90 cm, and therefore sufficient ballast to achieve a cushion pressure of at least this value would be needed. As the ballasting operation proceeded periodic checks of cushion pressure were made. With 14 ballast blocks aboard and the trim tanks filled, a cushion pressure of 76 cm was achieved. With 19 blocks the pressure was 80 cm and with 21 blocks it was 82.5 cm. With this amount of ballast, the all-up weight of the craft was 281 t. On the basis of previous experience it was estimated that the cushion pressure would increase to 90 cm when the ACIB was notched to the ALEXANDER HENRY, therefore, no additional ballast was added. Ballasting to achieve greater pressure was not considered adviseable because of the uncertain condition of the skirts and notch segments.

The preparations were completed on 22 March and the test scheduled for 23 March. It had been arranged between the Master of the ALEXANDER HENRY and the ARCTECH Instrumentation Engineer that the ACIB/ALEXANDER HENRY would proceed further into the slip only on receipt of confirmation from the ARCTECH Engineer that the forces being imposed on the slip press were within limits.

On the morning of 23 March, prior to notching with the ACIB, the ALEXANDER HENRY broke out a turning area off the Keefer Terminal dock. The ensuing notching operation was accomplished successfully, but it was complicated by the low freeboard of the craft and the amount of ice trapped between the ACIB and the ALEXANDER HENRY. With the ACIB ballasted to 281 t, the freeboard was only 0.49 m. With a slight stern-down attitude due to the off centre load of the trim ballast, the notch segments were virtually awash. As the ALEXANDER HENRY moved into the notch, ice was pushed onto the top of the notch segments. Attempts to push the ice off the segments with pike poles met with only limited success. An attempt to free the notch of ice was made by bringing the ACIB up on hover, however, the trapped ice prevented the notch segments from inflating and the craft assumed a 15° nose-up attitude. Finally, the ice was cleared by slackening off on the notch and transit cables and having the ALEXANDER HENRY move astern a few metres. As the ice cleared, the notch segments inflated and the ACIB levelled itself.

Following the notching operation, the ACIB/ALEXANDER HENRY proceeded directly to the area in front of the Manitoba Pool slip. Enroute the cushion pressure was checked and found to be 86 cm. This measurement was made over broken ice and it was anticipated that it would rise to 90 cm over the unbroken ice in the slip. This proved to be the case. The cushion pressure achieved was adequate to break the 71 cm ice in the slip entrance and the progressively thicker ice further into the slip to the 90 cm ice in the inner area opposite the workhouse.

The test proved to be eminently successful. The ACIB/ALEXANDER HENRY broke a path 32 m wide with some degree of breaking taking place up to the slip walls. At one point, the ice ruptured ahead of the craft in a line down the centre of the slip for a distance of about 30 metres. The broken ice pieces were about 2 m per side, or less, which was much smaller than achieved in unconfined areas. Although the temperatures had moderated over the previous three days, nevertheless, the ice in the slip broke in a manner characteristic of brittle ice

and not that of the resilient ice encountered on 20 and 21 March. This could be attributed to the fact that the ice in the slip was sheltered from the sun's rays by the adjacent grain elevator.

Following the slip test, tracks were opened between the south entrance and the main entrance inside the breakwater. The ice in this area had been broken earlier in the season and had refrozen to depths up to 75 cm. This ice was broken with no difficulty. At speeds of 2 knots, the path width achieved was 32 m, and the piece size was as large as 4.5 m by 6.0 m. Speeds over previously broken and partially refrozen ice in this area reached 4 knots with the ALEXANDER HENRY engines operating at 210/220 RPM.

Although the speeds achieved during the runs inside the breakwater were not considered excessive, nevertheless, damage to skirt segments in the port side aft areas of the ACIB occurred. This was evidenced by excessive spray issuing from under the spray apron in this area. A short run outside the breakwater in the vicinity of the south entrance was attempted. However, it appeared that the damage was getting progressively worse, as the spray increased and the cushion pressure dropped to 76 cm. The decision was therefore made to return to base and beach the ACIB for inspection and repairs.

The ACIB was beached on 24 March following the removal of the ballast blocks and the filling of the trim tanks. The inspection revealed that there were tears in six skirt segments and three notch segments. The repairs were completed on 26 March and the ACIB launched on the same day.

3.3.7 Further Operations In Resilient Ice

On 27 March, following completion of repairs, operations with the ACIB/ALEXANDER HENRY resumed. The plan of operations was to widen and maintain tracks to open water and also in the vicinity of the terminals, in preparation for the imminent arrival and departure of ships.

During the preceding 5 days, the mean temperature averaged -3°C and the daily maximum averaged +2°C. It was, therefore, anticipated that resilient ice conditions similar to those encountered on 20/21 March would pertain, and that a cushion pressure of 76 cm would be required to break the 60 cm ice that would be encountered in widening the tracks. To this end the ACIB was ballasted to an all-up weight of 222 t. With its engines operating at 1800 RPM, cushion pressures of 74 to 79 cm were achieved depending on ice surface roughness.

On 27 March, the tracks from the breakwater main entrance to open water off the Welcome Islands were re-opened and widened. Six passes over this route were made as shown in Figure 10.

Over previously broken and partially refrozen ice, speeds of 4 to 5 knots were achieved with the ALEXANDER HENRY's engines operating at 210/220 RPM. In unbroken ice 50 to 60 cm thick similar speeds were obtained. The piece size was 2.4 m by 3.0 m, similar to that encountered in brittle ice. However, in 68 cm ice, the combination was slowed to 1 to 2 knots and the piece size was predominantly 6 m by 6 m. It was apparent that the cushion pressure of 77 cm was only marginally adequate for ice of this thickness and condition. In ice of 76 cm thickness, which was encountered off the established track, the ACIB/ALEXANDER HENRY was brought to a halt and several passes were required to break through the area of thicker ice.

By the nature of the operation, over 70% of the distance covered was over previously broken ice. This situation, coupled with speeds that rose to 5 knots on several occasions, was damaging to the skirts and notch segments. During the latter part of the operation on 27 March, it was observed by underdeck video camera sweeps that at least 3 skirt soles had been torn. There was also evidence that some damage to the notch segments had occurred, in that the amount of spray from the notch area had increased during the course of the operation. These conditions were not considered serious enough to curtail further operations, and the decision was made to continue operations with the ACIB/ALEXANDER HENRY on 28 March.

The plan of operations for 28 March was to re-open and widen the turning areas off the slips inside the north and south entrances of the breakwater. The first run of the day was a circular pass from the Keefer Terminal to the CN One Dock and out the south entrance. In this pass, 90 cm thick ice was encountered on two occasions. With a cushion pressure of only 74 cm the combination was, as to be expected, brought to a halt. Because of the proximity to an area of broken ice, it was possible to break through the region of thick ice by two or three backing and ramming manoeuvres.

Subsequently, four passes outside the breakwater, between the south and north entrances, and three circular passes inside the north entrance were made. All but about 2 km of the distance covered was over previously broken ice.

Although the speed over the broken ice did not exceed 4 knots, except for a few short intervals, nevertheless, considerable damage to the skirts and notch segments resulted. This was evidenced by a drop in cushion pressure from 74 to 68 cm and an increasing amount of spray issuing from the notch area. Additionally, a sweep with the underdeck video camera showed that at least 5 skirt soles were loose and there was a possible rip in the outer face of one skirt segment.

Since the cushion pressure had not dropped to a dangerous level, an attempt was made to open a track from the south entrance to Mutton Island. Shortly after starting along this track, ice 68 cm thick was encountered and the ACIB/ALEXANDER HENRY was brought to a halt as a result of inadequate cushion pressure for the ice conditions.

Since no further profitable work could be done with the craft in its current condition, the decision was made to return to base and beach the ACIB for inspection and an assessment of the feasibility of further icebreaking with the ACIB.

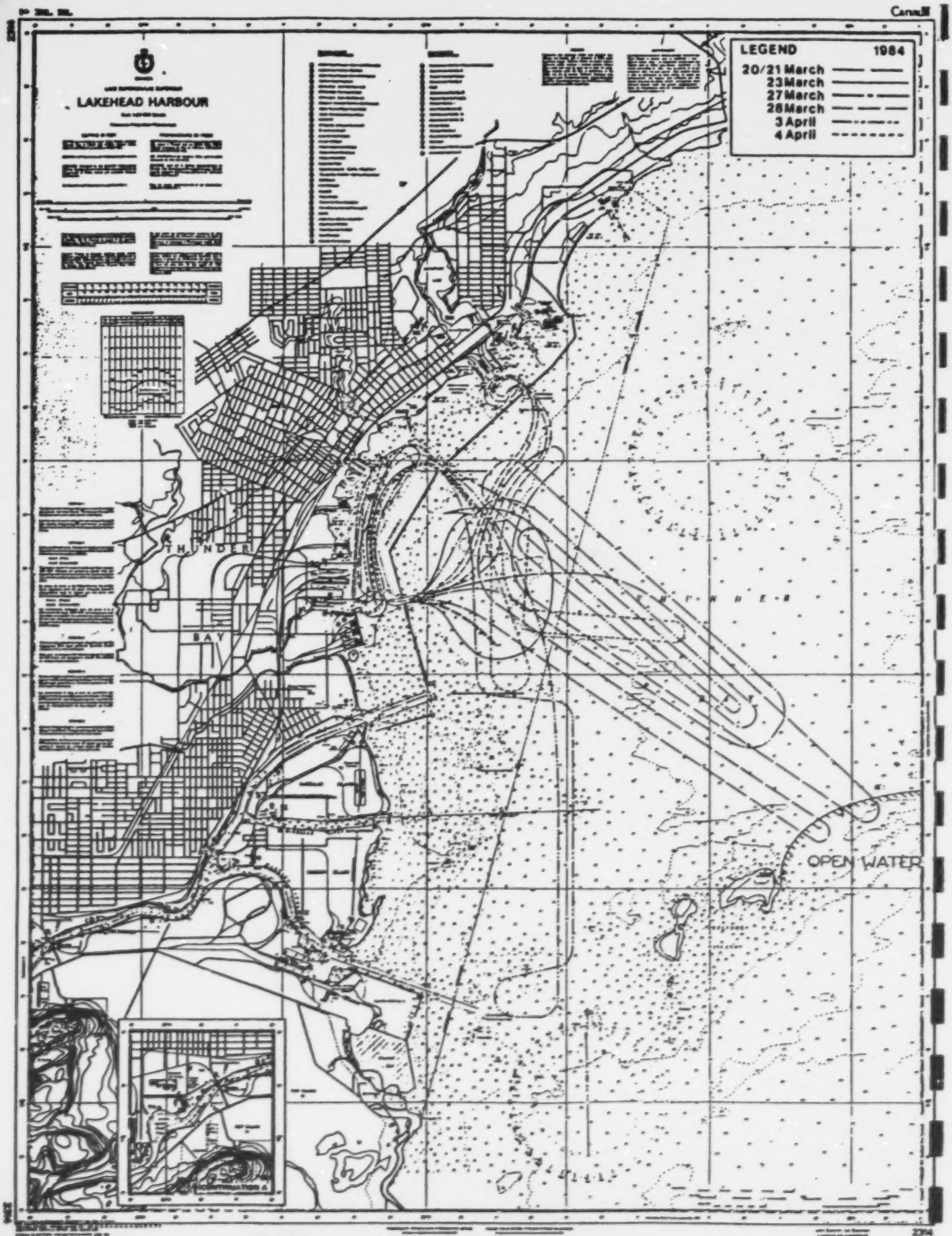
The craft was beached and inspected on 29 March. The inspection revealed that 8 skirt segments and 5 notch segments were damaged and it was estimated that the necessary repairs could be completed in three days. Since TDC wished to determine the craft's capability for breaking the 68 cm soft ice with the craft adequately ballasted, and further, since the Master of the ALEXANDER HENRY wished to have the use of the ACIB when escorting ships in and out of the harbour, the decision was made to proceed with the repairs and put the ACIB back in service as quickly as possible. Accordingly, the repairs were carried out in the period 30 March to 1 April and the craft launched on 2 April.

3.3.8 Operations in Decaying Ice

On 2 April, the ACIB was launched and ballasted with 11 blocks which gave it an all-up weight of 232.4 t, exclusive of trim ballast. At this weight, cushion pressures of 76 to 80 cm were achieved depending on ice roughness conditions.

Although the ACIB was ready for operations on 2 April, it was not used until 3 April, as the ALEXANDER HENRY was engaged in work not requiring the ACIB on 2 April.

On 3 April, tracks were made from the Keefer Terminal to the main entrance inside the breakwater and from the main entrance to the Mission River entrance outside the breakwater. These tracks are shown in Figure 10. The ice encountered on that day was for the most part 45 to 50 cm thick and in a decaying condition with the lower half being extensively honeycombed. (Photo). The clear skies and daytime high temperatures that averaged +5°C during the previous 5 days had caused rapid decay of the ice. However, with cushion pressures of 76 to 80 cm water gauge, no difficulty was experienced in breaking this ice. For most of the distance covered on that day, the tracks were either in or adjacent to previously broken tracks.


LAKEHEAD HARBOUR
LEGEND 1984
20/21 March
23 March
27 March
28 March
3 April
4 April
THUNDER
BAY
OPEN WATER

Speeds in the unbroken ice parallel to the old tracks were 3 knots with ALEXANDER HENRY's engines operating at 150/160 RPM and 4 knots with them operating at 190/200 RPM. The size of the pieces of broken ice was as much as 3.5 m to 4.0 m. The large size was possible due in some measure to the proximity to previously opened tracks.

After some 7 hours of operations, the ACIB/ALEXANDER HENRY returned to base for the night. Operations were resumed on 4 April with the objective of maintaining tracks for the movement of ships, which then numbered 6 in the harbour area, and also for the fuelling and servicing of the lighthouse at the main entrance. The initial runs were made in the vicinity of Pool 6 to widen a turning area for the imminent departure of the freighter TADOUSSAC. Later in the day, runs were made outside the breakwater to widen the tracks from the main entrance to the Kaministiquia River entrance and from the main entrance to a point one mile off the Welcome Islands. These tracks are shown in Figure 10.

During a pass outside the main entrance, an area of unbroken ice 60 cm thick was encountered. With the cushion pressure at 80 cm, no difficulty was experienced in breaking this ice. A speed of 5 knots was achieved through this ice with the ALEXANDER HENRY's engines operating at 225/230 RPM. The path width was 32 m and the piece size 2.5 m by 3.0 m. In broken tracks, a speed of 6 knots was achieved with the engines at the same speed.

At the end of the day's operation on 4 April, the Master of the ALEXANDER HENRY released the ACIB from operations as he could foresee no further use for it at that time. The ACIB crew welcomed this decision because it was felt that further operations would result in a deterioration of the condition of the skirts which might result in further loss of cushion pressure and hover height and compromise beaching of the ACIB on the ballast blocks.

Subsequently, on 6 April, the ACIB was beached for the season.

3.3.9 End-Of-Season Beaching Operation

On 5 April, in preparation for the beaching of the ACIB, the 22 ballast blocks were positioned on the beaching area in the pattern shown in Figure 9. The ballast blocks were used, as they had been in the previous year, to raise the beached ACIB to a more convenient height for work on the skirts and notch segments. A successful beaching operation was carried out on 6 April, with the ACIB's buoyancy tanks being positioned squarely on the ballast blocks.

During its beaching operation, the craft's over-pressure lifted and ruptured the asphalt beaching pad in several places. Also, the escaping air under the skirts plowed deep furrows in the loose sand on the lakeside edge of the pad. Repairs to the pad prior to next season's operations will be required.

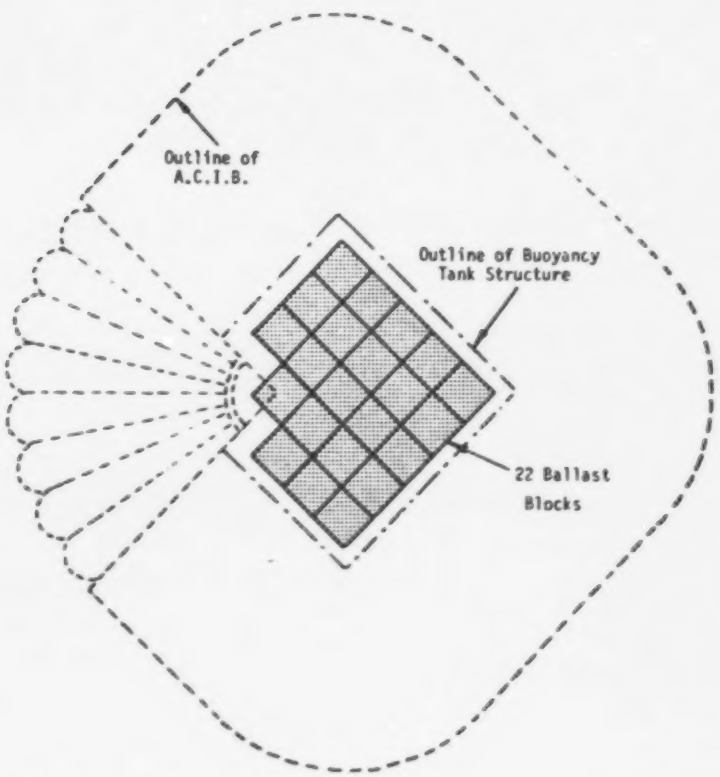


FIGURE 11: LAYOUT OF BALLAST BLOCKS FOR FINAL BEACHING

3.4 PERFORMANCE SUMMARY

3.4.1 Introduction

This section presents comments and observations on the performance and operational characteristics of the ACIB/ALEXANDER HENRY combinations.

3.4.2 Fuel Consumption - ALEXANDER HENRY

Fuel consumption of the ALEXANDER HENRY was measured on 11 days of operations with the ACIB. The results are listed in Figure 12. The measurements were taken from the ship's fuel gauges on departure from, and return to, the CCGS dock. The consumption figures and running times shown in Figure 12 have been adjusted to discount those amounts used during the backing manoeuvres to get the ACIB/ALEXANDER HENRY clear of the dock. This operation at times took as much as 40 minutes. The adjustments were made in order to give a truer measure of the fuel consumed per hour of icebreaking time and per kilometer of ice broken.

The average fuel consumption during the 11 days of operations for which measurements were taken was 42.6 litres per kilometer and 269 litres per hour of running time.

The variations in consumption rates can be related to the nature of the ice conditions encountered and the type of operation performed. The consumption per kilometer of travel and per hour of running time are discussed separately in the following sections.

3.4.2.1 FUEL CONSUMPTION PER KILOMETER

The low consumption rates of 34.7 and 37.5 litres/km obtained on 23 February and 1 March respectively, can be attributed to optimum conditions of operation, in which long sustained runs in smooth snow-free ice were made at optimum speeds of 3 to 4 knots.

The higher consumption rates on 28 February, 2 and 3 March, which averaged 46.2 litres/km, are attributed to the nature of the operation, in which numerous backing and turning manoeuvres were made in previously broken and refrozen ice in the inner harbour area. These operations were carried out in support of the movement of the ALGOLAKE from Pool 6 to the shipyard dock. The operations on 28 March, for which the consumption was 46.2 litres/km, could also be included in this group as they entailed manoeuvring in the inner harbour area.

The higher consumption of 47.7 and 51.2 litres/km on 6 and 7 March can be attributed to the snow cover which amounted to 5 to 10 cm. Although similar snow cover conditions existed on 8 March, the consumption was lower at 36.2 litres/km. This could be attributed to the fact that approximately half of the distance covered was in thin ice, 15 to 30 cm, where speeds of 4 to 5 knots were achieved at engine speeds averaging 200 RPM. Similarly, the low consumption rates achieved on 3 and 4 April resulted from the relatively high speeds of 4 to 5 knots which were achieved at low engine speeds when operating in, or adjacent to, previously broken tracks in decaying ice.

3.4.2.2 FUEL CONSUMPTION PER HOUR

The per hour fuel consumption rates are related to the average engine speeds which pertained over the entire running time of each day's operation. By the nature of the operations performed, engine speeds were varied frequently. This was particularly the case for icebreaking operations in the inner harbour area, where numerous backing and turning manoeuvres were performed. The rates shown in Figure 12 are therefore averages for the particular type of operation performed. Extended continuous runs on 23 February and 1 March, at moderate engine speeds of 190 to 200 RPM, resulted in a fuel consumption averaging 261 litres/hr. Extended runs on 6, 7 and 8 March, at the relatively high engine speed of 230 to 240 RPM, resulted in an average consumption of 315 litres/hr. The low rate of 216 litres/hr achieved on 3 March resulted from the low speeds maintained while the ACIB/ALEXANDER HENRY escorted the ALGOLAKE in tow from Pool 6 to the

shipyard dock. Similarly, low consumption resulted from the low engine speeds which were maintained on 28 March and 3 April when the icebreaking combination was operating in, or adjacent to, broken tracks in decaying ice. A good correlation between engine speeds and fuel consumption was obtained from the results of operations on 3 and 4 April. On 3 April, extended runs at low engine speeds, averaging 175 RPM, resulted in a fuel consumption of 211 litres/hr; whereas, on 4 April, similar runs at engine speeds averaging 225 RPM resulted in a consumption rate of 262 litres/hr.

DATE	FUEL CONSUMED (l)	TIME RUNNING (h:m)	DISTANCE (km)	RATES	
				l/km	l/hr.
23 Feb.	868	3:22	25.0	34.7	258
28 Feb.	817	3:09	19.4	42.1	259
1 Mar.	1044	3:57	27.8	37.5	264
2 Mar.	1385	4:15	29.6	47.9	326
3 Mar.	1082	5:00	22.2	48.7	216
6 Mar.	1412	4:37	29.6	47.7	306
7 Mar.	1516	4:42	29.6	51.2	322
8 Mar.	1878	5:54	51.9	36.2	318
28 Mar.	1580	7:29	34.1	46.2	212
3 Apr.	1280	6:05	32.4	40.6	211
4 Apr.	1336	5:00	37.0	36.1	267
			AVERAGES:	42.6	269

NOTE: "Fuel consumed" and "Time running" are adjusted to discount that used in moving away from the CCGS dock.

FIGURE 12: ALEXANDER HENRY FUEL CONSUMPTION

3.4.3 Turning Radius

Although no specific turning radius tests were performed during the 1983/84 operations, nevertheless, this characteristic was observed on several occasions during the operational period. As to be expected, the results were essentially the same as those measured during the 1982/83 trials, In open water, with both engines operating at 200 RPM and the rudder hard over, the turning radius of the ACIB/ ALEXANDER HENRY combination was 0.2 km. In 40 cm ice, with both engines at 200 RPM and the rudder hard over, it was 0.9 km. In well broken and unfrozen ice, the turning radius was essentially the same as in open water, that is, 0.2 km.

3.4.4 Freeboard vs. Weight

Freeboard versus weight measurements were made during ballasting operations with the following results:

WEIGHT (t)	BALLAST	FREEBOARD (m)
187.5	None	1.00
203.7	4 blocks	0.97
216.0	7 blocks	0.91
232.4	11 blocks	0.79
281.0	21 blocks, trim ballast	0.50

3.4.5 Cushion Pressure and Hover Height vs. Weight

As noted in Section 3.4, the icebreaking performance narrative, cushion pressure and hover height varied markedly with speed, ice surface condition and the condition of the skirts and notch segments. A more consistent indication of these characteristics versus ACIB weight is obtained from the measurements taken with the ACIB/ALEXANDER HENRY combination stationary and made a short time after ACIB launching following repairs. These measurements are listed below.

WEIGHT (t)	ENGINE SPEED (RPM)	CUSHION PRESSURE (Cm H_2O)	HOVER HEIGHT (m)
203.7	1600	68	3.35
212.7	1600	70	3.50
212.7	1800	74	3.65
222.0	1600	72	3.50
222.0	1800	77	3.81
232.4	1600	76	3.35
232.4	1800	79	3.50
281.0	1800	86	3.05

3.4.6 Effects of Speed and Ice Surface Condition

Variations in speed and ice surface condition had a very pronounced effect on ACIB cushion pressure and hover height and to a lesser degree on fore-to-aft trim angles.

In operations over previously unbroken ice, it was noted that as the speed increased from 2 knots to 6 knots, there was an increase in cushion pressure of 2.5 cm and a concurrent increase in hover height of 0.3 m. It was postulated that this increase of cushion pressure was due to the containment of the air bubble under the ice by the rapid motion of the craft.

It was also observed that the fore-to-aft trim angle increased by approximately 0.5° (bow up) as the speed increased from 2 to 6 knots. This was attributed to the fact that the ice was breaking ahead of the craft a distance of some 2 m at the lower speed. The forward skirt segments were therefore in contact with ice slabs that were at a lower level than the unbroken ice surface. As the speed increased, the breaking occurred inside the skirts and those in the forward area were riding on the higher unbroken ice surface.

The effects of ice surface roughness on cushion pressure and hover height was noted on several occasions in passing from areas of smooth unbroken ice to areas of broken and refrozen ice and vice versa. In general, the areas of broken ice had blocks protruding up to 0.6 m above the base ice surface level. In passing from an area of broken ice to smooth ice, there was a pronounced increase in cushion pressure of 2.5 to 3.8 cm and a commensurate increase of hover height of up to 0.3 m. It was judged that this was due to the increased containment of air over the smooth ice.

3.4.7 Operations in Resilient Ice

The ice encountered during operations on 20/21 March 1984 did not exhibit the brittle fracture characteristics of that which was encountered during operations in late February and early March 1984. On several days prior to 20 March, the daytime high temperatures had risen above the freezing point with the result that the ice became more flexible. It was noted from the underdeck video camera coverage of the ice slabs entering under the bow area of the ACIB that they had a tendency to bend somewhat before breaking off. This was significantly different from the characteristics noted in the earlier periods where the entering ice slabs would remain rigidly suspended until a critical length was reached and then break off cleanly.

It became apparent during operations on 20/21 March that a cushion pressure 110% of ice thickness was inadequate to break this resilient ice. On at least one occasion when the ACIB cushion pressure had fallen to 66 cm, the craft failed to break the 60 cm ice that had been encountered and the ACIB/ALEXANDER HENRY combination was brought to a halt. On the other hand, the cushion pressure of 66 to 69 cm was quite adequate to break 50 cm ice.

It appeared that a cushion pressure equal to 130% of ice thickness would be required for operations in resilient ice.

3.4.8 Operations in Thin Ice

The operations in thin ice which occurred in the Mission River on 8 March 1984 were in effect operations with an excessive overpressure for the ice conditions. In this instance, the watergauge cushion pressure was over 4 times that of the ice thickness with the result that the ice was breaking explosively 10 m to 20 m ahead of the craft. With the ACIB/ALEXANDER HENRY combination proceeding at 5 knots, the characteristic bounding motion occurred as cushion pressure fluctuated through a wide range as air was expelled through successive ruptures ahead of the craft. The sharp slabs of 15 cm ice passed under the craft in a turbulent motion that resulted in serious damage to 3 skirt segments in a short period of time.

By reducing the speed to 4 knots, the bounding motion of the ACIB was stopped, however, the potential for damage by the thin slabs of ice remained. It was evident that operations in thin ice should be avoided, and where unavoidable, should be performed at very low speeds, certainly no more than 3 knots.

3.4.9 Operations in Previously Broken Ice

Extended operations in previously broken and unrefrozen ice such as those performed in the harbour area on 29 February, 2 March and 3 March 1984, have the potential for greater damage to skirt segments than operations over previously unbroken ice particularly where speeds over 4 knots occur. On these days, the objective was to break the ice slabs into smaller pieces in preparation for the movement of the freighter ALGOLAKE. The ACIB itself had no affect in this regard and the further breaking of the ice slabs was due to their impacting on the ship's hull. Wherever possible, it would be preferable to do this work with the ship alone thus avoiding the potential for damage to skirt and notch segments.

3.4.10 Operations in Decaying Ice

The decaying ice encountered on 3 and 4 April 1984 was less resistant to breaking than the resilient ice encountered on 20/21 March. The lower half of the decaying ice was extensively honeycombed with the result that only the upper half retained any tensile strength. A cushion pressure equivalent to 130% of ice thickness was adequate to break this type of ice.

4.0 MAINTENANCE

4.1 GENERAL

Over the operating season, the majority of maintenance work carried out on the craft was related to the skirt and notch systems. The craft required beaching for repairs on five occasions, and all were related to skirt damage.

All skirt and notch segments show signs of aging and breakdown of composition due to the effects of ultraviolet rays and general weathering.

Engines were very reliable over the season although hoses failed on two occasions, causing approximately one hour down time on each.

The clutch on the port engine failed during operations on the 28 February, but the craft continued operations for 5 days on two engines, whilst awaiting delivery of a replacement clutch assembly.

4.2 EMERGENCY REPAIRS

4.2.1 Clutch Failure

During icebreaking operations on 28 February 1984, whilst notched to the CCGS ALEXANDER HENRY, the clutch on the port drive unit failed. The fan began to spin in reverse, causing a drop in cushion pressure, and a change in attitude of the craft.

The port engine was shut down, the inlet guide vanes were closed, and the water ballast tank at the port side was emptied. The speed of the other engines was increased from 1600 RPM to 1800 RPM.

The craft continued operations and operated for a period of five days on two engines, until the clutch on the port engine was replaced.

Two significant items came to light as a result of this incident:

1. The fuel consumption figures for these five days showed that the two engines running at 1800 RPM consumed a total of 200 litres per hour of fuel. Three engines at 1600 RPM consume a total of 270 litres per hour.

2. There was no significant difference in cushion pressure or hover height as against those measured for three engines at 1600 RPM.

Operation on two engines at 1800 RPM apparently gives a significant reduction in fuel consumption, about 25%, without significant performance loss, and on further investigation it was discovered that 1800 RPM is the recommended, so presumably optimum, operating speed for the fan. It is also a better speed for engine operation, and suggests the possibility of operating the engines in pairs in rotation to reduce running time and permit progressive maintenance. It is recommended that the question of two engine operation as routine should be investigated further.

A consideration of safety must be made if this course of action is to be followed. At present, slippage and consequent failure of clutches cannot be detected other than by sight of smoke, or by smell, by which time it may be too late to save the clutch from burning out.

The relevant fan ceases to deliver air, and goes into a reverse mode, expelling as much air from the plenum as one other fan is delivering. Tachometers should be fitted on the fans to allow a direct comparison to be made between engine speed and fan speed, and automatic guide vane controls should be linked to fan speed rather than engine speed, to ensure their closure in the event of a clutch failure.

4.2.2 Skirt Segments

As the "protective" sole plates appeared to be of dubious value on the skirts at the forward sides of the craft, it was decided to repair the sole plates only when the damage was minor, and to use rivets to

forestall delamination of the bonded joints. Where damage was extensive, the sole plates were removed from the forward segments, but were repaired on the rear segments.

Since the majority of damage incurred by the skirt segments was to sole plates, the removal of those damaged at the forward sides eliminated any requirement for further repairs. On a few occasions, damage was incurred in the base of segments. Skirts had been folded and stored open to the weather, creating a weak spot at the fold in the face. The closed sole, and consequent entrapment of ice within the segment meant that the ice was bounced around, until it found the weak spot.

4.2.3 Notch

Damage to the notch segments, although being the reason for beaching on only two of the five occasions, was present in all instances. The soles of notch segments Nos. 4 and 5, which are the segments which fit against the hull of the host ship, were extensively damaged and even reverting to the original flapped sole configuration did not prevent further damage. All of the notch segments required repair at some time during the season, and the notch as a whole proved to be the weakest link in the system.

4.3 BEACHING

4.3.1 Techniques

Once performed and experienced by personnel, the beaching operation became very simple since every crew member knew what was required.

The craft was pulled along the wharf to the beach area and was beached using its own winches to pull it ashore while on hover.

4.3.2 Beaching Area

The beaching area at present is barely adequate for servicing and repairs. The craft is beached between a corrugated steel building, a transformer, and a gasoline fuel tank. The work area is poorly drained.

Prior to beaching the craft for summer lay-up, the ballast blocks were set on the beach pad, in a configuration suitable for supporting the craft. The craft was then carefully aligned and set upon the blocks.

The beach, however, suffered a good deal of damage as air escaping from under the skirts undercut the asphalt pad and eroded a large section.

4.4 FINAL INSPECTION AND LAY-UP

A final inspection of the craft was carried out, prior to lay-up and all damage and deficiencies were listed.

A 500-hour service, in accordance with the engine manufacturer's service manual has been performed on all of the engines, and various small replacement items have been listed.

4.5 CHARACTERISTICS OF MAINTAINABILITY

The craft as a whole is very easily maintained. Maintenance checks were carried out at every instance required by the manual and proved to be fully adequate.

General maintenance and repairs and, in particular, the removal and replacement of skirts, became increasingly more efficient as the crew gained experience in the procedures.

A complete set of "as built" drawings is required to aid in fault finding in respect to the hydraulic, electric, and instrumentation systems, since a number of modifications have been made on these systems since construction and have not been fully documented.

4.6 COSTS

Costs involved in operation during the 1983/84 season were as follows:

Labour (including overtime)	$110,000
Site costs	31,000
Travel and Living	18,000
Repairs and Modifications	115,000
Emergency Repairs	31,000
Skirt material and aluminum tube	7,000
Instrumentation	11,000

NOTE:

SITE COSTS - Include the cost of hiring a crane to load and unload ballast blocks, and the costs of fuelling heaters and generator.

REPAIRS AND MOFIDICATIONS costs are essentially for work which could be performed during the lay-up season.

Operational costs can be significantly reduced by the following means:

a) Undertake repairs and modifications during the summer lay-up period, eliminating the need for premium rated overtime hours.

b) Utilize trained crew members from the host vessel for operation and performance of emergency repairs.

c) Incorporate the site costs and maintenance facility into the existing base at Thunder Bay.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The 1983/84 operations were conducted successfully with the ACIB/ALEXANDER HENRY combination demonstrating once again a marked superiority in operational efficiency and economy over the ship alone.

Major accomplishments were as follows:

1. Carried out repairs and made good a number of evident deficiencies arising from previous test program.

2. Conducted a full ice management program:

   - 170.9 hrs of diesel engine operation;
   - 155 hrs of hovering on cushion during overland, overwater and icebreaking trials;
   - Opened 486 km (262 nm) of new channels through ice from 35 to 66 cm in thickness (14-26 in);
   - Over 5 days of operations, carried out on two engines following a clutch failure*. No interference with operational task.

   *Fuel Consumptions: 3 engines at 1600 RPM - 270 litres/hr
   2 engines at 1800 RPM - 200 litres/hr
   These settings give same cushion pressure and hover height.
   1800 RPM is recommended operating speed for fans.

3. Provided Canadian Coast Guard personnel with extensive 'hands on' experience with the ACIB.

4. Broke ice with ALEXANDER HENRY at speeds up to 6 knots.

5. Broke out a slip in which the ice thickness was 0.90 m (36 in) over a large area. ALEXANDER HENRY alone produced unacceptable loads on wharf structure while still on approach.

6. The improvement in spray suppression brought about by adding a flap to the top of the spray apron was quite appreciable.

Engines, fans and other operating equipment performed satisfactorily, with the exception of a single clutch failure, which did not interfere with operations. It is evident that the modification program recommended and applied has been successful in this area.

Modification of the skirt segment soles was not satisfactory, and a great deal of effort was put into maintaining them until it was concluded that they were not required on the forward segments and that the original design, which did not trap ice, was superior for the rear segments. Very little trouble was experienced after a decision was made to remove damaged soles.

The notch segments take a great deal of abuse, particularly during notching and unnotching. they also suffer from damage caused by ice pieces being turned up on edge by the parting action of the flared ship's bow, while they are still in the skirt/spray apron area. This effect is particulary marked at high speed, when pieces can be seen to emerge on edge with up to 50% of their volume protruding above the waterline. The notch is unquestionably a high damage area by the very nature of its operation and geometry.

It can be concluded that considerable gains are possible in the serviceability of the skirt system, and may be brought about by the following means:

1. Removal of sole plates from all segments in locations 12 through 56.

2. Return to original flap soles on notch segments and main segments in locations 1 through 11 and 57 through 67.

3. Provision of a pushing arrangement which will permit the notch segments to be fully deployed at all times.

Lessons have been learnt from the skirt system of the ACIB which will be invaluable in future designs. These lessons have already been incorporated in new concept designs being prepared by German & Milne for TDC.

During the 1983/84 operations, it became evident that the present ballasting arrangement with concrete blocks is not only undesirable from an operational standpoint, but is also a safety hazard. With the craft loaded to obtain a cushion pressure equivalent to 1 m of water, there would be no reserve buoyancy, and even at 281 t the freeboard is less than 0.5 m off cushion. A liquid ballast system is considered essential for safety as well as for operational reasons if the craft is to be certified.

Another item which deserives attention is the possibility of routine operation on two engines. During the five days of operation necessitated by the failure of the port engine clutch, it was found that not only was there little difference in pressure and flow between operation on two engines at 1800 RPM and three engines at 1600 RPM, but that two engine operation gave nearly 25% improvement in fuel consumption. It is interesting to note that in a notched hover test on 7 March 1983 at 263.7 t (see TP 4446A, Table 6) the following performance was obtained:

- 3 engines, 1600 RPM, cushion pressure 77.7 cm, hover height 2.10 m
- 2 engines, 1800 RPM, cushion pressure 88.9 cm, hover height 2.77 m
- 1 engine, 1800 RPM, cushion pressure 80.3 cm, hover height 2.38 m
- 1800 RPM is the recommended operating speed for the fan.

It has been noticed that all operations with the ACIB have been on a learn as you go basis, and that this has led to damage being incurred because the Master of the CCGS ALEXANDER HENRY has had no guidance regarding the capabilities and limitations of the craft. There is no doubt that the Operations Manual will be helpful, but it is considered that something more related to an understanding of the handling characteristics of the ACIB/ship combination is required. As

a start, a short note entitled "Air Cushion Icebreaking Bow - Guide For Operators" has been prepared, and is included as Appendix "*". It is suggested that this might be used as the basis for a CCG document.

5.2 RECOMMENDATIONS

It is considered that the ACIB has now demonstrated its capabilities as a valuable ice management accessory. There is no question that it can enhance the icebreaking performance of a ship by a factor as great as ten, depending on the ice condition, while at the same time reducing fuel cost and wear and tear on the hull and power train. Manoeuvrability is also improved and icebreaking in circumstances otherwise impossible can be completed, as was demonstrated in breaking out slips. The question now is whether the principle of air cushion icebreaking is to be exploited in Canada and, in particular, how this affects the future of the ACIB.

It has already been decided that the ACIB will be used again in the 1984/85 ice management program at Thunder Bay and in this connection, the following recommendations are made:

1. That no changes are made to the present configuration of the ACIB.

2. That only such work as is considered necessary to ensure satisfactory service through the 1984/85 season should be carried out.

3. That a survey and cost estimate for repairs and overhaul should be completed as soon as possible.

4. That a contract for repair and overhaul should be placed as soon as possible, but not later than mid-August, because the lead time on such items as skirt material is 12 weeks, and it is necessary that the work should be properly planned, be carried out in favourable weather and with no overtime. The contract should include provision of support services through the 1984/85 season.

5. That CCG provide only a deck officer to the ACIB, and that contractor's personnel should be responsible to this officer for operational and engineering support. Unless CCG wishes to assume on the spot responsibility for engineering and management decisions, a CCG engineer officer is not required.

After the 1984/85 icebreaking season, and assuming that the Type 1050 cutter to be established at Thunder Bay arrives in time for the 1985/86 season, a decision will have to be made on the future of the ACIB. Three options appear to be available:

A. Refit, to enhance handling and reliability, and certification.
B. Place in long-term storage.
C. Disposal.

It seems unreasonable to store or dispose of a piece of equipment which can serve a useful purpose, especially when it is really only a prototype and has been operated in only one area. Interest has been expressed in using an ACIB to keep open the Port of Chicoutimi year round, and also the Goose Bay area at the west end of Lake Melville. Apart from any value to CCG, and surely it must have some, this example of Canadian technology should be demonstrated to potential users, both Canadian and foreign. For the U.S., for example, it could be demonstrated in Duluth, but it does not need to go to Chicoutimi or Goose Bay for those interested to witness its possibilities. And there may be interest overseas from Scandinavia, say, or Korea.

It is recommended that the ACIB should undergo a refit, with the object of incorporating modifications to improve handling and reliability, and of obtaining certification. The modifications should include:

1. A liquid ballast system.
2. A fail-safe inlet guide vane control for the fans.
3. Re-design of the electrical system.
4. Rationalization of the hydraulic system.

5. A single enclosure to include all 3 engines and fans, the auxiliary power unit, a workshop, a store, an office/messroom and a control room.

6. A paint scheme to make the ACIB smarter in appearance and recognizable as a CCG craft.

7. In place of the notch, a re-designed section which will be a trial installation for a second generation ACIB.

It is further recommended that this refit should be funded for FY 1985/86 so that it can be started as soon as 1984/85 operations are completed.

APPENDIX "A"

CANADIAN COAST GUARD ACIB - 1983/84 OPERATIONS

W O R K P L A N

CANADIAN COAST GUARD ACIB - 1983/1984 OPERATIONS

CONTRACT NO. OSZ83-00081

WORK PLAN

1. OBJECTIVE

The objective of the task is to obtain pertinent data on hardware, performance and operations of the ACIB during the 1983/1984 ice management season in Thunder Bay for an adequate assessment of its effectiveness under the following conditions:

- At the beginning of the winter season
- Under severe winter conditions (cold, wind and precipitation)
- Icebreaking up to 1m ice thickness (design maximum)

The ACIB will be used in combination with the CCGS ALEXANDER HENRY and the tug THUNDER CAPE, and it will be the task of the German and Milne team to:

- Evaluate the performance of the ACIB/THUNDER CAPE combination in the conditions given above, as well as its effectiveness in breaking ice in leads and around piers under the auspices of the Thunder Bay Ice Management Task Force
- Monitor and document the operational performance and the maintainability of the ACIB
- Perform all necessary maintenance required for proper functioning of the ACIB
- Collaborate with and advise the CCG in the operation of the ACIB and the resolving of problems

2 PERSONNEL

The German and Milne personnel involved in this task will be the same as for the 1982/1983 season, namely:

J. A. Tarzwell	-	Field Manager
C. Carter	-	Operations Engineer
G. Sundell	-	Operations Supervisor
P. Markham	-	A/Field Manager and Liaison

A technician will be hired in Thunder Bay to assist with minor repairs and modifications not considered to warrant the cost of subcontracting.

3 ORGANIZATION AND ADMINISTRATION

In order to achieve better operational and financial control, and provide more rapid response to urgent situations, the focus of management has been transferred to Thunder Bay, where Mr. Tarzwell will have responsibility for the budget and authority to make expenditures within budget limits.

Messrs Carter and Sundell will be responsible for the operation and maintenance of the ACIB, and Mr. Markham will carry out any liaison with CCG in Ottawa or TDC in Montreal. It is also proposed that Mr. Markham will relieve Mr. Tarzwell in Thunder Bay for two weeks during the operational period in order to share responsibility and experience.

When the ACIB is laid up, Mr. Sundell will remain on site to carry out any remaining tasks, and the others will return to Ottawa, where Messrs Tarzwell and Markham will prepare the Summary Report, and Mr. Carter will be responsible for revising the Operating and Maintenance Manuals.

4 SUBCONTRACTORS

It is intended to use the same subcontractors as during the 1982/1983 season, namely:

- Vulcan Machinery and Equipment Ltd. for mechanical and electrical work.

- Rematech Industries Division of Rubbertex Corp. Ltd. for rubber work.

It should be noted that Rematech Industries now have the capability to carry out hot bonding.

The tug THUNDER CAPE will be chartered from Western Engineering Service Ltd.

5 MAINTENANCE FACILITY

The maintenance facility at the CCG Sub-Base Thunder Bay is already in position from previous contracts, and only requires reconnection of electrical power and telephone services. A pick-up truck will be rented, and other services, such as fuel and a crane, are available on request.

Tools and equipment are available on inventory, and the only requirement from last year is a ratchet chain puller (come-along). Survival suits (4) are being purchased to replace unserviceable items, and an arc welding set is also being procured.

Minor spares are available, either in stock or from local suppliers.

Secretarial services are available locally. The work load does not warrant the employment of a secretary or the renting of office equipment.

The mailing address and Telex numbers are as follows:

ACIB Trials Office
c/o Canadian Coast Guard Sub-Base
P.O. Box 2746
Thunder Bay "P", Ontario
P7B 5G2 Telex: 073-4328

The telephone number of the ACIB Trials Office is (807)345-0412

6 REPAIRS AND MODIFICATIONS

Repairs and modifications are required before the ACIB can be made operational. The sum of money allowed in the contract for these items is $129.102.00, which was arrived at by estimate. Fixed price subcontracts with Vulcan and Rematech will be negotiated before work is started in order to ensure that the work is completed within budget.

The following items are involved:

Rematech

- Repair all skirt segments, including notch segments
- Manufacture 3 spare skirt segments
- Manufacture new wear aprons
- Manufacture new secondary spray apron

Vulcan

- Repair notch booms
- Revise engine cooling system
- Revise remote control panel
- Replace 4 fairleads with Port Colborne type
- Modify transit winches for 7/8 in. cable
- Weld deck seams
- Repair carousel
- Install additional under-deck lights(4)
- Install additional deck lights
- Cover electrical wiring and hydraulic lines on deck
- Manufacture fittings for secondary spray apron

German & Milne personnel will carry out certain work in addition to the above, as follows:

- Reinstall expanded metal walkways
- Cover fire extinguisher heads (3)
- Reinstall engine covers
- Install reserve fuel tank
- Install skirt segments and spray aprons

Painting will have to be deferred until lay-up.

7 MONITORING EQUIPMENT

It is proposed to use the same instrumentation for data gathering as was used in the 1982/1983 season, and the following parameters will be recorded:

i ACIB

- Hover height
- Hover pressure
- Trim angles
- Weight
- Engine speed
- Fuel consumption

ii ALEXANDER HENRY

- Speed (video monitor with real time display)
- Engine speed (one shaft) both sides of fluid coupling (real time record)
- Fuel consumption
- Ramming cycles

iii THUNDER CAPE

- Speed (equipment as for ALEXANDER HENRY)
- Engine speed
- Fuel consumption

iv ICE

- Thickness
- Snow cover
- Surface temperature
- Water temperature
- Structure (photograph of edge)
- Size and shape of average pieces

v METEOROLOGICAL

- Air temperature
- Wind speed and direction
- Precipitation

Operations and maintenance log books will be kept, as well as a general diary.

Photographic and video records will be made as appropriate.

A chart will be maintained on which tracks and other appropriate information will be recorded.

8 OPERATIONS WITH THUNDER CAPE

The modifications made to the THUNDER CAPE last season are essentially intact, and very little work, other than removal of fenders, is required prior to operation with the ACIB. It has already been arranged that, once removed, fenders will not be replaced until work with the ACIB is completed, unless specifically required for some other charter.

It is proposed to operate strictly on an as-required basis, and consideration is being given to taking the ACIB to the THUNDER CAPE, rather than vice versa, in order to save time and money.

The ACIB will be operated in the manned mode because of the otherwise restricted visibility. There will be a maximum of two men on board when under way.

The objectives are stated in para 1 above, and an attempt will be made to explore the full capability of the combination in regard to pure icebreaking and to its utility in breaking ice in confined areas.

These operations will be carried out under the general direction of the G&M Field Manager.

9 OPERATIONS WITH CCGS ALEXANDER HENRY

The ACIB/ALEXANDER HENRY combination will be used at the discretion of Captain John McDonald, of the ALEXANDER HENRY, and operated by CCGS personnel. G&M will be responsible for the maintenance of the ACIB, and providing assistance and advice to CCG personnel if required.

It is intended that the ACIB will be operated in the unmanned mode.

10 EMERGENCY REPAIRS

A sum of $30,000 has been budgeted for emergency repairs (unscheduled maintenance).

Authorization for expenditure will normally be obtained from the Scientific Authority before work is started, but responsibility is delegated to the Field Manager if he cannot be reached. In any case, the following procedure will be followed:

1. G&M Field Manager will attempt to contact Scientific Authority by telephone for approval.

2. G&M Field Manager will address Telex to Scientific Authority, either:
   - acknowledging approval
     or
   - outlining situation and advising action being taken, including overtime estimate.

11 CONTROL OF FIELD EXPENSES

The Field Manager will be responsible for the control of field expenses, and will maintain separate records for each of the Direct Cost budgets below:

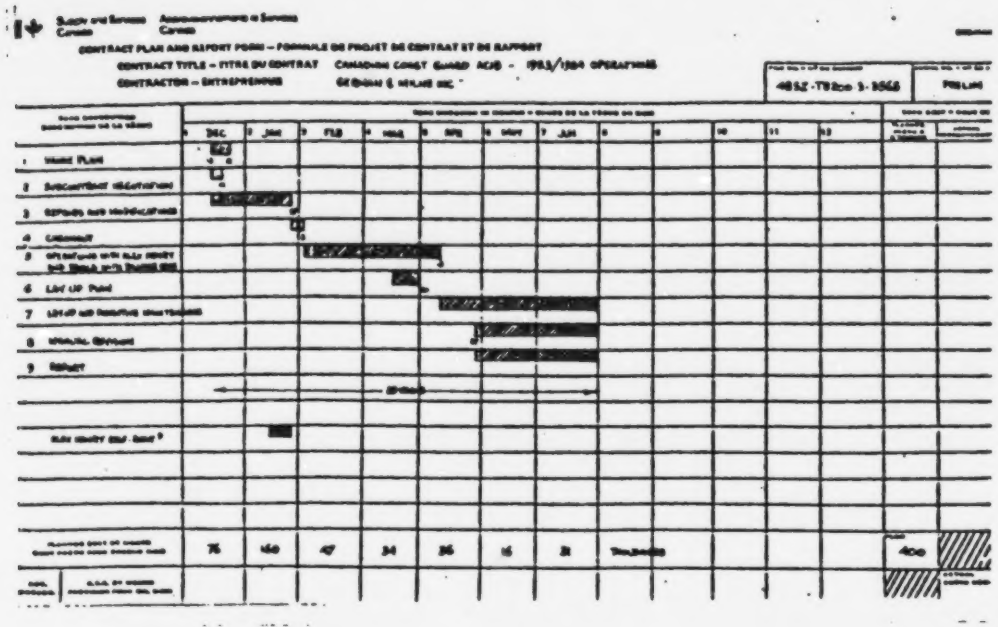
- Fuel, lubricants, site costs, crane, video equipment, film, office supplies and other miscellaneous items	$35,000.00
- Instrumentation, including inspection camera, video equipment and RPM monitoring equipment	$14,000.00
- Charter of tug ($550/h x 36h)	$19,800.00
- Subcontracts	$129,102.00
- Emergency repair funds	$30,000.00

The cost of items will be identified as a commitment (estimate) or expenditure (invoiced cost) in order that a running balance may be maintained.

The Field Manager will notify G&M Comptroller when the budget expenditure for any specific task approaches 75%, in order that DSS and TDC may be advised.

12 SCHEDULE

A revised schedule is given below.



APPENDIX "B"

CANADIAN COAST GUARD ACIB - 1983/84 OPERATIONS

METEOROLOGICAL SUMMARY

Environment Canada / Environnement Canada

Atmospheric Environment Service / Service de l'environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS DECEMBER/DÉCEMBRE 1983

AT/À THUNDER BAY "A" ONTARIO

LAT 48 22 N LONG 89 19 W ELEVATION/ALTITUDE: 199 METRES (ASL) / MÈTRES (NMM) STANDARD TIME USED / HEURE NORMALE UTILISÉE EASTERN / EST

DATE	TEMPERATURE / TEMPÉRATURE			DEGREE-DAYS / DEGRÉS-JOURS		REL. HUMIDITY / HUMIDITÉ REL.		THUNDERSTORM / ORAGE	PRECIPITATION / PRÉCIPITATIONS			SNOW ON GROUND / NEIGE AU SOL	WIND / VENT			BRIGHT SUNSHINE / INSOLATION EFFECTIVE
	MAXIMUM / MAXIMALE °C	MINIMUM / MINIMALE °C	MEAN / MOYENNE °C	HEATING / DE CHAUFFE BASE 18.0°C	GROWING / DE CROISSANCE BASE 5.0°C	MAXIMUM / MAXIMALE %	MINIMUM / MINIMALE %		RAINFALL / PLUIE (HAUTEUR) mm	SNOWFALL / NEIGE (HAUTEUR) cm	TOTAL PRECIP / PRÉCIP TOTALE mm	cm	AVERAGE SPEED / VITESSE MOYENNE km/h	PREVAILING DIRECTION / DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION / VITESSE MAXIMALE ET DIRECTION km/h	HOURS / HEURES
1	-5.9	-14.4	-10.2	28.2		92	62			TR	TR	11	15.6	SVRL	28 WSW	0.8
2	-8.1	-19.1	-13.6	31.6		92	57			TR	TR	11	19.2	W	33 W	6.7
3	-2.3	-21.8	-12.1	30.1		86	64			0.2	0.2	9	7.4	SVRL	19 WSW	3.3
4	-1.7	-12.4	-7.1	25.1		85	63					8	15.9	W	28 WNW	4.8
5	-7.4	-20.2	-13.8	31.8		85	62			TR	TR	8	11.2	NW	19 SVRL	3.8
6	-10.9	-22.3	-16.6	34.6		77	47					8	8.0	SW	13 SVRL	5.5
7	-9.0	-22.5	-15.8	33.8		79	57					8	6.3	SVRL	13 SSW	0.0
8	-7.9	-20.8	-14.4	32.4		85	38			0.2	TR	8	18.9	W	32 WNW	3.2
9	-15.6	-27.4	-21.5	39.5		69	38					8	12.5	SW	19 W	6.7
10	-11.0	-26.9	-19.0	37.0		85	50			2.8	1.9	8	14.9	WSW	28 ENE	2.6
11	-1.1	-11.6	-6.4	24.4		100	85			20.4	19.4	14	20.0	E	28 SVRL	0.0
12	-2.0	-18.4	-10.2	28.2		86	67			TR	TR	29	15.6	WNW	24 WNW	6.6
13	-7.3	-16.8	-12.1	30.1		92	78			6.6	5.5	29	11.5	N	26 NE	0.0
14	-6.8	-9.1	-8.0	26.0		92	67			0.2	TR	35	15.8	NNE	28 NNE	0.0
15	-9.1	-19.2	-14.2	32.2		72	50			1.0	1.0	35	24.0	N	32 N	0.0
16	-16.8	-22.5	-19.7	37.7		70	50			0.2	0.2	35	13.1	NW	20 W	3.4
17	-19.9	-27.6	-23.8	41.8		64	48			TR	TR	33	16.4	W	26 WNW	6.9
18	-24.4	-31.9	-28.2	46.2		68	43			TR	TR	30	16.8	W	28 NW	6.7
19	-22.2	-33.3	-27.8	45.8		63	48					28	16.5	SVRL	26 W	7.5
20	-18.6	-30.3	-24.5	42.5		69	49					26	12.5	SVRL	22 SW	7.5
21	-5.9	-23.9	-14.9	32.9		92	64			11.8	7.7	26	8.4	SSE	32 SSE	0.0
22	-10.1	-23.4	-16.8	34.8		92	54			1.6	1.0	36	24.0	WSW	33 SVRL	0.2
23	-21.5	-27.6	-24.6	42.6		58	52			TR	TR	36	32.3	WSW	39 W	5.9
24	-20.1	-24.3	-22.2	40.2		58	48			TR	TR	34	39.0	W	54 W	4.3
25	-15.4	-27.2	-21.3	39.3		71	52			1.0	0.8	30	27.4	WSW	35 WSW	3.5
26	-8.2	-17.8	-13.0	31.0		78	65			TR	TR	28	23.2	WSW	33 W	0.0
27	-11.0	-21.2	-16.1	34.1		92	56					27	8.7	W	20 W	3.1
28	-13.1	-22.8	-18.0	36.0		78	53			TR	TR	25	18.8	W	30 SVRL	3.9
29	-15.8	-26.3	-21.1	39.1		64	45			TR	TR	23	22.0	WSW	33 W	6.0
30	-8.0	-19.7	-13.9	31.9		85	40					22	12.1	WSW	28 WSW	6.8
31	-10.4	-21.6	-16.0	34.0		72	47					22	11.5	SVRL	20 N	7.8
MEAN / MOYENNE	-11.2	-22.1	-16.7	TOTAL 1074.9	TOTAL	79	55	TOTAL 0	TOTAL 0.0	TOTAL 46.0	TOTAL 37.7		16.8	PREVAILING W	MAXIMUM 54 W	TOTAL 117.5
NORMAL / NORMALE	-5.8	-16.3	-11.1	901.1				0	4.1	46.2	41.7		14.0	W		93.4

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C / AU-DESSOUS DE 18°C	THIS YEAR / ANNÉE EN COURS	PREVIOUS YEAR / ANNÉE PRÉCÉDENTE	NORMAL / NORMALE	ABOVE 5°C / AU-DESSUS DE 5°C	THIS YEAR / ANNÉE EN COURS	PREVIOUS YEAR / ANNÉE PRÉCÉDENTE	NORMAL / NORMALE
TOTAL FOR MONTH / TOTAL DU MOIS	1074.9	798.4	901.1	TOTAL FOR MONTH / TOTAL DU MOIS			
ACCUMULATED SINCE JULY 1 / ACCUMULÉE DEPUIS LE 1er JUILLET	2234.1	2188.7	2227.4	ACCUMULATED SINCE APRIL 1 / ACCUMULÉE DEPUIS LE 1er AVRIL			

DAYS WITH TOTAL PRECIPITATION: / JOURS AVEC PRÉCIPITATIONS TOTALES: mm

0.2 OR MORE / OU PLUS	1.0 OR MORE / OU PLUS	2.0 OR MORE / OU PLUS	10.0 OR MORE / OU PLUS	50.0 OR MORE / OU PLUS
9	6	3	1	0

DAYS WITH SNOWFALL: / JOURS AVEC CHÛTE DE NEIGE: cm

0.2 OR MORE / OU PLUS	1.0 OR MORE / OU PLUS	2.0 OR MORE / OU PLUS	10.0 OR MORE / OU PLUS	50.0 OR MORE / OU PLUS
11	7	4	2	0

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Canada

Environment Canada / Environnement Canada

Atmospheric Environment Service / Service de l'environnement atmosphérique

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS JANUARY/JANVIER 1984

AT/À THUNDER BAY "A" ONTARIO

LAT: 48 ° 22 'N LONG: 89° 19 'W ELEVATION: ALTITUDE: 199 METRES (ASL) MÈTRES (NMM) STANDARD TIME USED: HEURE NORMALE UTILISÉE: EASTERN EST

DATE	TEMPERATURE TEMPÉRATURE			DEGREE-DAYS DEGRÉS-JOURS		REL. HUMIDITY HUMIDITÉ REL.		THUNDERSTORM ORAGE	PRECIPITATION PRÉCIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE	MINIMUM MINIMALE	MEAN MOYENNE	HEATING DE CHAUFFE	GROWING DE CROISSANCE	MAXIMUM MAXIMALE	MINIMUM MINIMALE		RAINFALL PLUIE (HAUTEUR)	SNOWFALL NEIGE (HAUTEUR)	TOTAL PRECIP. PRÉCIP. TOTALE		AVERAGE SPEED VITESSE MOYENNE	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION	
	°C	°C	°C	BASE 18.0°C	BASE 5.0°C	%	%		mm	cm	mm	cm	km/h		km/h	HOURS HEURES
1	-8.3	-20.6	-14.5	32.5		85	61			0.2	0.2	22	6.0	SSW	13 SW	0.4
2	-3.4	-13.9	-8.7	26.7		85	58					22	10.7	SW	24 W	5.5
3	6.0	-8.2	-1.1	19.1		85	69		0.6	TR	0.6	21	22.8	WSW	46 W	2.2
4	3.4	-16.1	-6.4	24.4		85	61		TR	0.2	0.2	17	17.5	N	41 E	3.0
5	0.2	-14.4	-7.1	25.1		93	67			3.5	2.7	17	13.1	NW	43 WNW	0.0
6	-7.0	-19.3	-13.2	31.2		85	49			TR	TR	20	10.3	NNW	43 NNW	3.5
7	-1.6	-14.1	-7.9	25.9		92	61		TR	6.2	3.5	21	12.3	WNW	43 NW	0.7
8	-13.9	-24.4	-19.2	37.2		69	45					26	17.5	WNW	46 WNW	6.8
9	-11.8	-27.5	-19.7	37.7		70	51			TR	TR	25	14.3	SVRL	32 NW	0.1
10	-20.9	-28.7	-24.8	42.8		63	40					25	14.0	W	24 NW	8.0
11	-21.2	-31.8	-26.5	44.5		68	44					25	9.8	SW	19 SSW	4.8
12	-13.5	-25.7	-19.6	37.6		78	46			0.8	0.5	25	6.5	WSW	15 ENE	4.6
13	-9.6	-17.4	-13.5	31.5		85	71			3.6	2.2	26	10.0	SSW	19 NW	1.0
14	-15.6	-29.9	-22.8	40.8		71	42			TR	TR	29	12.3	SSW	20 NW	7.8
15	-5.9	-30.8	-18.4	36.4		77	49			TR	TR	26	15.5	SW	35 SSW	4.1
16	-8.1	-23.2	-15.7	33.7		85	42			0.6	0.3	24	20.0	W	30 WSW	5.5
17	-18.2	-30.0	-24.1	42.1		69	44					24	16.2	WSW	28 W	7.4
18	-19.9	-31.2	-25.6	43.6		75	44					24	11.7	WSW	19 SVRL	7.4
19	-21.5	-31.0	-26.3	44.3		75	47			0.3	0.2	24	13.5	SVRL	30 WNW	0.7
20	-24.4	-34.6	-29.5	47.5		61	43					24	18.0	W	26 SVRL	7.5
21	-15.0	-34.4	-24.7	42.7		69	46			0.2	TR	24	11.9	WSW	26 WSW	4.4
22	-14.9	-30.7	-22.8	40.8		75	52			4.4	3.6	24	4.5	WSW	11 SVRL	0.0
23	-2.2	-22.4	-12.3	30.3		86	64			TR	TR	28	5.7	S	20 S	0.0
24	1.1	-8.1	-3.5	21.5		93	54			0.4	0.2	27	19.1	SVRL	59 W	1.5
25	-8.1	-18.0	-13.1	31.1		66	36					26	27.8	WNW	59 WNW	8.4
26	-8.5	-24.6	-16.6	34.6		85	46			1.5	1.1	26	10.0	SVRL	33 WNW	5.4
27	-8.4	-22.0	-15.2	33.2		85	39			3.0	2.2	27	18.6	W	37 WNW	5.1
28	-4.8	-12.1	-8.5	26.5		93	67			5.2	3.2	32	15.0	WNW	35 WNW	0.9
29	-9.2	-17.1	-13.2	31.2		72	56			TR	TR	33	12.3	W	32 WNW	3.6
30	-11.5	-23.8	-17.7	35.7		71	47			0.4	0.2	33	10.7	WSW	22 WSW	8.2
31	-7.8	-25.1	-16.5	34.5		85	63			TR	TR	33	4.7	SVRL	11 W	0.1
MEAN MOYENNE	-9.8	-22.9	-16.4	TOTAL 1066.7	TOTAL	79	52	TOTAL	TOTAL 0.6	TOTAL 30.5	TOTAL 20.9		13.3	PREVAILING WSW DOMINANTE	MAXIMUM 59 SVRL	TOTAL 118.6
NORMAL NORMALE	-9.4	-21.3	-15.4	1034.9					1.9	48.4	40.9		14.1	W		118.4

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C AU-DESSOUS DE 18°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE	ABOVE 5°C AU-DESSUS DE 5°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE
TOTAL FOR MONTH TOTAL DU MOIS	1066.7	911.1	1034.9	TOTAL FOR MONTH TOTAL DU MOIS			
ACCUMULATED SINCE JULY 1 ACCUMULÉE DEPUIS LE 1er JUILLET	3300.8	3099.8	3262.3	ACCUMULATED SINCE APRIL 1 ACCUMULÉE DEPUIS LE 1er AVRIL			

DAYS WITH TOTAL PRECIPITATION: JOURS AVEC PRÉCIPITATIONS TOTALES: mm

0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS
15	7	6	0	0

DAYS WITH SNOWFALL: JOURS AVEC CHUTE DE NEIGE: cm

0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS
15	7	6	0	0

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MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS FEBRUARY/FEVRIER 1984

AT/À THUNDER BAY "A" ONTARIO

LAT 48° 22 'N LONG 89 ° 19 'W ELEVATION: ALTITUDE: 199 METRES (ASL) MÈTRES (NMM) STANDARD TIME USED: HEURE NORMALE UTILISÉE: EASTERN EST

DATE	TEMPERATURE TEMPÉRATURE			DEGREE-DAYS DEGRÉS-JOURS		REL. HUMIDITY HUMIDITÉ REL.		THUNDERSTORM ORAGE	PRECIPITATION PRÉCIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE °C	MINIMUM MINIMALE °C	MEAN MOYENNE °C	HEATING DE CHAUFFE BASE 18.0°C	GROWING DE CROISSANCE BASE 5.0°C	MAXIMUM MAXIMALE %	MINIMUM MINIMALE %		RAINFALL PLUIE (HAUTEUR) mm	SNOWFALL NEIGE (HAUTEUR) cm	TOTAL PRECIP. PRÉCIP. TOTALE mm	cm	AVERAGE SPEED VITESSE MOYENNE km/h	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION km/h	HOURS HEURES
1	-3.2	-10.1	-6.7	24.7		92	74			0.4	0.3	33	5.6	SW	17 W	0.0
2	-0.5	-9.4	-5.0	23.0		93	79		TR	5.6	5.6	38	22.5	E	41 E	0.0
3	-3.5	-10.4	-7.0	25.0		85	68			1.4	0.8	39	16.7	W	32 W	0.2
4	-8.1	-18.0	-13.1	31.1		85	62			1.9	1.6	40	12.0	NNE	37 N	4.9
5	-17.8	-28.0	-22.9	40.9		69	41			0.2	0.2	40	19.9	N	37 NNE	8.0
6	-14.4	-30.4	-22.4	40.4		69	38			TR	TR	40	6.5	SSW	11 SVRL	3.4
7	-9.4	-21.2	-15.3	33.3		71	47			TR	TR	40	11.8	WSW	19 W	5.9
8	1.7	-13.4	-5.9	23.9		79	44					40	9.1	WSW	22 SW	6.5
9	1.0	-13.6	-6.3	24.3		93	64					35	4.8	SVRL	20 SSE	6.1
10	-0.2	-13.9	-7.1	25.1		100	85					33	6.0	SVRL	17 NE	0.0
11	3.4	-3.9	-0.3	18.3		100	75					32	7.7	W	15 ENE	0.9
12	1.4	0.2	0.4	17.6		93	80		9.8	0.6	10.4	29	21.9	ENE	41 ENE	0.0
13	4.0	0.6	2.3	15.7		100	75		12.3	TR	12.3	25	16.1	ENE	32 ENE	0.2
14	5.4	1.2	3.3	14.7		87	61		TR	TR	TR	20	17.9	WSW	37 WSW	0.0
15	1.9	0.5	1.2	16.8		86	75					14	14.8	E	26 E	0.0
16	3.2	-0.8	1.2	16.8		93	75					14	16.4	ENE	28 ENE	1.9
17	3.8	-1.6	1.1	16.9		93	75		1.0	0.2	1.2	13	10.8	ENE	32 ENE	0.0
18	3.8	-3.3	0.3	17.7		93	60					13	12.3	SW	20 N	0.9
19	1.1	-7.4	-3.2	21.2		80	55					13	18.7	N	35 N	4.6
20	0.8	-8.4	-3.8	21.8		85	64					13	13.2	W	35 WNW	0.6
21	2.2	-2.7	-0.3	18.3		86	60			TR	TR	13	10.4	S	20 WSW	0.0
22	9.7	-6.6	1.6	16.4		93	53					13	4.5	W	13 ENE	7.5
23	2.0	-3.9	-1.0	19.0		93	64			TR	TR	12	11.3	N	28 NNW	0.1
24	-3.7	-8.0	-5.9	23.9		68	49			TR	TR	10	16.8	NNW	32 NNW	0.6
25	-3.5	-13.1	-8.3	26.3		72	46			TR	TR	10	13.7	NNW	26 N	10.1
26	0.0	-16.1	-8.1	26.1		85	40					9	13.9	SW	30 W	10.1
27	0.1	-10.5	-5.2	23.2		67	50			TR	TR	8	8.3	SW	20 N	3.9
28	-2.7	-12.1	-7.4	25.4		67	42					8	20.0	N	19 SVRL	9.6
29	-7.0	-17.0	-12.0	30.0		71	35					8	18.9	NW	39 NW	10.3
MEAN MOYENNE	-1.0	-9.7	-5.4	TOTAL 677.8	TOTAL	84	60	TOTAL	TOTAL 23.1	TOTAL 10.3	TOTAL 32.4		13.2	PREVAILING N	MAXIMUM 41 SVRL	TOTAL 96.3
NORMAL NORMALE	-6.2	-19.8	-13.0	876.5					1.9	30.7	28.3		13.5	W		146.7

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C AU-DESSOUS DE 18°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE	ABOVE 5°C AU-DESSUS DE 5°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE
TOTAL FOR MONTH TOTAL DU MOIS	677.8	722.9	876.5	TOTAL FOR MONTH TOTAL DU MOIS			
ACCUMULATED SINCE JULY 1 ACCUMULÉE DEPUIS LE 1er JUILLET	3978.6	3822.7	4138.8	ACCUMULATED SINCE APRIL 1 ACCUMULÉE DEPUIS LE 1er AVRIL			

DAYS WITH TOTAL PRECIPITATION: JOURS AVEC PRÉCIPITATIONS TOTALES: mm

0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS
8	5	3	2	0

DAYS WITH SNOWFALL: JOURS AVEC CHUTE DE NEIGE: cm

0.2 OR MORE – OU PLUS	1.0 OR MORE – OU PLUS	2.0 OR MORE – OU PLUS	10.0 OR MORE – OU PLUS	50.0 OR MORE – OU PLUS
7	3	1	0	0

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MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE MÉTÉOROLOGIQUE MENSUEL

MONTH/MOIS MARCH / MARS 1984

AT/À THUNDER BAY "A" ONTARIO

LAT: 48° 22 'N LONG: 89° 19'W ELEVATION: ALTITUDE: 199 METRES (ASL) MÈTRES (NMM) STANDARD TIME USED: HEURE NORMALE UTILISÉE: EASTERN EST

DATE	TEMPERATURE TEMPÉRATURE			DEGREE-DAYS DEGRÉS-JOURS		REL. HUMIDITY HUMIDITÉ REL.		THUNDERSTORM ORAGE	PRECIPITATION PRÉCIPITATIONS			SNOW ON GROUND NEIGE AU SOL	WIND VENT			BRIGHT SUNSHINE INSOLATION EFFECTIVE
	MAXIMUM MAXIMALE °C	MINIMUM MINIMALE °C	MEAN MOYENNE °C	HEATING DE CHAUFFE BASE 18.0°C	GROWING DE CROISSANCE BASE 5.0°C	MAXIMUM MAXIMALE %	MINIMUM MINIMALE %		RAINFALL PLUIE (HAUTEUR) mm	SNOWFALL NEIGE (HAUTEUR) cm	TOTAL PRECIP. PRÉCIP. TOTALE mm	cm	AVERAGE SPEED VITESSE MOYENNE km/h	PREVAILING DIRECTION DIRECTION DOMINANTE	MAXIMUM SPEED AND DIRECTION VITESSE MAXIMALE ET DIRECTION km/h	HOURS HEURES
1	-3.8	-17.4	-10.6	28.6		60	23					8	16.5	NW	30 NW	10.3
2	-2.9	-15.7	-9.3	27.3		66	21					8	10.4	NNW	22 NW	7.2
3	-0.8	-15.9	-8.4	26.4		73	32					6	5.3	SVRL	17 S	0.0
4	1.4	-7.3	-3.0	21.0		93	43			0.4	0.2	5	3.7	E	13 ESE	2.8
5	-2.9	-20.9	-11.9	29.9		93	49			3.4	2.6	7	17.4	N	35 N	0.1
6	-15.0	-26.5	-20.8	38.8		57	32			TR	TR	8	13.3	SVRL	24 NNW	9.4
7	-12.7	-28.7	-20.7	38.7		64	36					8	6.5	WSW	15 E	9.2
8	-7.4	-25.6	-16.5	34.5		64	23					8	9.5	SVRL	24 W	9.5
9	-7.4	-26.2	-16.8	34.8		63	24					7	13.5	WSW	32 W	9.6
10	-4.7	-20.9	-12.8	30.8		78	35			0.4	0.2	7	27.3	SW	72 WNW	1.4
11	-15.6	-27.0	-21.3	39.3		58	29			0.2	0.2	7	23.7	W	56 WNW	9.5
12	-10.0	-28.2	-19.1	37.1		85	39			0.2	0.2	7	9.4	E	19 SE	7.3
13	-3.8	-10.3	-7.1	25.1		92	68			2.6	2.2	9	4.0	SVRL	19 NE	0.0
14	3.2	-11.4	-4.1	22.1		92	70		0.4	0.4	0.8	9	11.9	ESE	35 S	0.0
15	1.5	-13.4	-6.0	24.0		100	53			5.2	5.2	13	13.9	N	32 NW	0.0
16	-10.9	-21.1	-16.0	34.0		66	33			TR	TR	13	11.9	SVRL	24 N	10.2
17	-7.0	-16.1	-11.6	29.6		79	65			0.2	0.2	13	19.2	E	33 ENE	0.0
18	-0.5	-20.1	-10.3	28.3		85	37					13	5.5	WSW	17 ENE	10.6
19	1.4	-17.3	-8.0	26.0		86	55					11	9.5	E	22 E	7.9
20	1.6	-2.9	-0.7	18.7		93	80		TR	2.5	2.7	7	8.0	NNE	28 N	0.0
21	2.3	-1.0	0.7	17.3		86	55			0.9	0.9	6	29.2	N	61 NNE	0.0
22	3.4	-3.6	-0.1	18.1		69	32			TR	TR	5	29.6	N	56 N	8.4
23	2.0	-9.3	-3.7	21.7		74	34					3	9.4	WSW	24 NNW	5.2
24	2.5	-7.6	-2.6	20.6		86	59					3	9.2	E	22 ENE	3.6
25	1.0	-9.3	-4.2	22.2		92	59					2	9.1	E	24 ENE	6.0
26	1.4	-9.9	-4.3	22.3		93	59					2	11.2	E	28 E	8.4
27	3.6	-8.3	-2.4	20.4		86	41					1	8.3	E	20 ENE	9.8
28	1.7	-7.4	-2.9	20.9		74	47					1	16.3	E	35 ENE	2.8
29	4.9	-2.8	1.1	16.9		64	38					1	20.8	NNE	32 N	6.4
30	6.5	-3.9	1.3	16.7		74	33					1	13.3	NNW	26 NNE	10.5
31	7.9	-7.0	0.5	17.5		86	36					1	8.3	SW	19 E	10.9
MEAN MOYENNE	-1.9	-14.3	-8.1	TOTAL 809.6	TOTAL	74	43	TOTAL	TOTAL 0.4	TOTAL 16.4	TOTAL 15.7		13.1	PREVAILING DOMINANTE E	MAXIMUM 72 WNW	TOTAL 176.0
NORMAL NORMALE	-0.2	-12.3	-6.3	752.5					13.7	34.2	45.0		13.8	E		172.8

DEGREE-DAY SUMMARY – SOMMAIRE DE DEGRÉS-JOURS

BELOW 18°C AU-DESSOUS DE 18°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE	ABOVE 5°C AU-DESSUS DE 5°C	THIS YEAR ANNÉE EN COURS	PREVIOUS YEAR ANNÉE PRÉCÉDENTE	NORMAL NORMALE
TOTAL FOR MONTH TOTAL DU MOIS	809.6	683.7	752.5	TOTAL FOR MONTH TOTAL DU MOIS			
ACCUMULATED SINCE JULY 1 ACCUMULÉE DEPUIS LE 1er JUILLET	4788.2	4506.4	4891.3	ACCUMULATED SINCE APRIL 1 ACCUMULÉE DEPUIS LE 1er AVRIL			

DAYS WITH TOTAL PRECIPITATION: JOURS AVEC PRÉCIPITATIONS TOTALES: mm

0.2 OR MORE - OU PLUS	1.0 OR MORE - OU PLUS	2.0 OR MORE - OU PLUS	10.0 OR MORE - OU PLUS	50.0 OR MORE - OU PLUS
11	4	4	0	0

DAYS WITH SNOWFALL: JOURS AVEC CHUTE DE NEIGE: cm

0.2 OR MORE - OU PLUS	1.0 OR MORE - OU PLUS	2.0 OR MORE - OU PLUS	10.0 OR MORE - OU PLUS	50.0 OR MORE - OU PLUS
11	4	4	0	0

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ACIB SUMMARY OF DAMAGE TO SKIRT SEGMENTS DURING 1983/84 ICEBREAKING SEASON

Legend:
P = Parted sole bond
L = Loose sole fingers
T = Torn sole
S = Damage to side wall
F = Damage to face
D = Damage to repairs
O = Converted to open sole
R = Repaired (Appendix "C")

SKIRT No.	INSP & REPAIRS 8 Mar. '84	INSP & REPAIRS 20/21 Mar.'84	INSP & REPAIRS 23/26 Mar.'84	INSP & REPAIRS 28 Mar.'84	INSP & REPAIRS 9 April '84
1	P L F R		R		L
2	P L R				L
3	L R				
4	F R		R		D
5	L R				
6	L F R				L
7	L T R				L
8	L F R				
9	L R				
10	S L R				
11	L R				
12					L
13	L R				D
14	L R				
15				P L R	L
16					
17					L
18					
19	P L O				
20	P L O				
21	P L O				
22	P O				
23			R	R	D
24				R	L
25				F R	
26					
27	L T R				
28					L
29	P L O		R		
30					
31		P O			
32				L T R	
33				L T O	
34				L F R	
35	P L O				
36				L O	
37				P O	
38					L
39					P L
40					P L
41	P L O				
42	P L O				
43	P L O				
44		P O			
45	P T O R				
46	P L T O				
47	P T O				
48	P L O				
49	P L R O				
50	P L O				
51				P L T O	
52	P L				
53				P O	
54				L	L
55				P F O	
56				P L R	P L
57					L
58				L	
59				L	L
60				P R	L
61				L R	
62				S R	L
63					L
64			R		
65			R		
66				L R	L
67					L

AC18 SUMMARY OF DAMAGE TO SKIRT SEGMENTS DURING 1983/84 ICEBREAKING SEASON

Legend: P = Parted sole bond; L = Loose sole fingers; T = Torn sole; S = Damage to side wall; F = Damage to face; D = Damage to repairs; @ = Converted to [illegible]; R = Repaired (Appendix "C")

SKIRT No.	INSP & REPAIRS 8 Mar. '84	INSP & REPAIRS 20/21 Mar.'84	INSP & REPAIRS 23/26 Mar.'84	INSP & REPAIRS 28 Mar.'84	INSP & [illegible] 9 April '84
1	P L F R		R		L
2	P L R				L
3	L R				
4	F R		R		D
5	L R				
6	L F R				L
7	L T R				L
8	L F R				
9	L R				
10	S L R				
11	L R				
12					L
13	L R				D
14	L R				
15				P L R	L
16					
17					L
18					
19	P L @				
20	P L @				
21	P L @				
22	P @				
23			R	R	D
24				R	L
25				F R	
26					
27	L T R				
28					L
29	P L @		R		
30					
31		P @			
32				L T R	
33				L T @	
34				L F R	
35	P L @				
36				L @	
37				P @	
38					L
39					P L
40					P L
41	P L @				
42	P L @				
43	P L @				
44		P @			
45	P T @ R				
46	P L T @				
47	P T @				
48	P L @				
49	P L R @				
50	P L @				
51				P L T @	
52	P L				
53				P @	
54				L	L
55				P F @	
56				F L R	P L
57					L
58				L	
59				L	L
60				P R	L
61				L R	
62				S R	L
63					L
64			R		
65			R		
66				L R	L
67					L

APPENDIX "D"

AIR CUSHION ICEBREAKING BOW - GUIDE FOR OPERATORS

1. PRINCIPLE OF OPERATION

The air cushion icebreaking bow (ACIB) is a device designed to enhance the icebreaking capability of the host ship by breaking the ice sheet ahead of the ship's stem. It does not clear ice, the ship must force its way through the broken ice much as any ship following an icebreaker, and it will not break into smaller pieces ice which has already been broken.

The ACIB is a displacement craft, the same as any other vessel, and its draft, the depth to which the water surface beneath the plenum chamber is forced by air pressure, is similarly related to its weight. If its draft exceeds the thickness of an ice sheet, air at plenum or cushion pressure will be forced under the ice. Consequently, when the craft moves forward, the ice sheet entering the plenum will be exposed to the same pressure on both its upper and lower surfaces, or, in other words, it will cease to be supported by the buoyant force of the water. Thus when some critical length, which is dependent on the ice conditions, has entered the plenum, the ice will fail under its own weight as a cantilever, and the edge of the sheet will break off.

For hard, brittle, winter ice, the cushion pressure in cm of water should be about 1.1 times the ice thickness in cm. However, for spring ice, which is more flexible, a factor of 1.3 or more will be required.

2. OPERATING GUIDE

i) Ensure that the ACIB is adequately ballasted to achieve a cushion pressure appropriate to the expected ice conditions (see above).

ii) When approaching the ACIB to mate up, try to avoid piling ice at the bow of the ship. Remember that the ACIB has to be pulled towards the ship, rather than vice versa, and it does not move easily off cushion.

iii) Before getting under way, ensure that the ACIB is over water or broken ice. It cannot break ice unless air can be forced down below the ice sheet, and this is not possible if it is standing on the sheet itself. It must start from an edge.

iv) When proceeding astern, do so at the minimum speed possible. The forward skirt segments of the ACIB are not protected against scooping up or catching on ice, which could cause damage. This is unlikely to occur at low speed.

v) When proceeding ahead, a speed will be found at which the ACIB/ship combination is most comfortable. That is, when a steady state is achieved in which ice is being broken continuously without strain on the ACIB, the ship's structure or the power train. For the ACIB/CCGS ALEXANDER HENRY combination, this speed has been found to about 4 knots for most conditions.

3. GENERAL COMMENTS

Remember that the ACIB is an accessory. Its use is unnecessary and uneconomical until the ice conditions approach the point at which the ship can no longer proceed at a steady speed on its own. The efficiency and economy of the combination only become effective at this point, and increase as the ice gets thicker.

Examples of conditions where the ship alone will be more effective are:

- Thin ice. And it should be noted that thin, hard ice is particularly damaging to the skirt segments of the ACIB. For the CCGS ALEXANDER HENRY, for example, use of the ACIB in ice less than 25 cm thick is unlikely to be economical.

- Previously broken ice. Using the ACIB to re-open previously broken tracks will have to be related to the amount of refreezing

which has taken place. This sort of ice is hard on the skirt segments of the ACIB, so, if the ship can proceed at a steady speed on its own in the conditions prevailing, use of the ACIB will be uneconomical.

Unnecessary use may cause unnecessary damage, which is costly to repair and involves down time. It may even keep the ACIB out of service when it really is required or result in a requirement for expensive overtime work.